YLEM
JOURNAL
Artists Using Science and Technology
Volume 27 Nos. 10 & 12 September/December 2007

The Dichotomy of Reality

"Quantum Man 2, small version" (2007) by Julian Voss-Andreae.
Steel, height 50-in (1.27-m). (© Julian Voss-Andreae)

THE DICHOTOMY OF REALITY

Rob Harle (Guest Editor)
http://www.robharle.com
harle@dodo.com.au

While doing research into Quantum Physics for my digital artwork I kept coming across the problem of the apparent incompatibility of quantum and classical mechanics. How does the weirdness of quantum with its probabilities and wave functions translate into big solid rocks and human beings? How can classical physics and quantum physics both be correct as descriptions of reality? It seems to me this is where the problem lies — neither system is an accurate and complete ontological description of fundamental reality. Each system is correct in its own world, or as Wittgenstein might have said, each is its own self-sufficient "language game." I decided on the theme *Dichotomy of Reality* for this issue of *YLEM Journal* because of the intractability of this problem and approached the artists and quantum physicists represented herein, as all are concerned with this problem in one way or another.

Cyborg Mindscape1
gilcee print digital artwork

C. S. Unnikrishnan conducts research into quantum gravity at Tata Institute of Fundamental Research in Mumbai, India and is especially concerned with "observables and unobservables" in this dichotomous situation.

Dr Jacqueline Boustany is a medical doctor practicing in Australia and is particularly interested in the role quantum mechanics plays in the art of emotional healing. Her contribution is a little unusual for the *YLEM Journal* but that's what makes it so interesting in my opinion.

Julian Voss-Andreae is a quantum physicist and sculptor. Many *YLEM Journal* readers will be familiar with Julian's extraordinary sculptures; his home base is Portland, Oregon.

Dr Len Martin agreed to write a piece on Australian artist Leigh Arnold. Leigh is severely dyslexic and has difficulty writing, but as you will see from his images he has no difficulty in translating complex mathematical formulae and concepts into stunning visual artworks.

George Weissmann is a quantum physicist currently working on a major publication concerned with a new approach to understanding Quantum Theory which he calls *The Quantum Paradigm*.

It seems a basic human trait to be totally and pathologically immersed in dualities. Things are either spiritual or material; they are mind or body; physics is either classical or quantum and so on. It is perhaps time to realise that a third position to many things may be the correct approach. For example, nothing can travel faster than the speed of light (classical), entangled particles influence each other nonlocally, instantaneously (quantum). Perhaps the answer is that both are correct relatively speaking (pun intended). In the world of lumps of rock Einstein is correct. In the subatomic world quantum is correct, you cannot measure the length in millimetres of a stick with a volt meter. You cannot have a rock influence another rock 100 kilometres apart instantaneously, because rocks have become something greater than particles, probabilities or waves at subatomic levels. It seems to me it is to become something greater that is the key to a better understanding of fundamental reality, and that means complexity. As complexity increases from an electron to a bird, for example, different measurements and rules must apply. Neither the micro nor macro worlds (to use simple convenient labels) exist independently of each other, they contain the essence of each other, so to speak, all the way up and all the way down. And perhaps further!

The recent work of Stephen Adler known as "emergent quantum theory" may explain how our existing quantum theory arises from "a pre-quantum level of physical fields as yet unknown to physics"(1). These fields may obey laws which are similar to that of classical physics. Adler's work on this pre-quantum field suggests that "fluctuations in his pre-quantum fields lead naturally to the collapse of quantum superpositions." This will happen all the more rapidly in large (macro) objects! Perhaps this explains why "A photon in a quantum superposition can, for example, pass through two narrow slits in a screen at the same time, yet we cannot walk through two doors simultaneously" (2).

That is, it now appears that quantum mechanics may not have the final word in the quest for an accurate description and understanding of reality. It will be a fascinating paradox and irony if quantum theory itself turns out to be dependant on the context in which it is employed and observed. I believe it is time to move on from a preoccupation with quantum "stuff" to define reality and start looking for the real ontological nature of the universe. Maybe Adler's work and the contributors to this issue of YLEM Journal will help resolve the dichotomy.

I think it is important to realise and accept that all theories are basically "works in progress," and all are at present (before the Singularity) mediated by our limited human conscious

The Dichotomy of Reality cont'd on page 3

YLEM FORUM

YLEM Forum: Math, Art and Religion
Wednesday, March 19, 6 pm
SomArts Gallery
934 Brannan btwn. 8th & 9th Sts.
San Francisco, CA 94106
Free! Open to the public

At this forum we will be speaking about Math, Art and Religion. We will explore the history of mathematics and its interaction with art and religion, and then we'll explore some creative uses of math in making art.

Dr. Neville Roberts is Professor of Mathematics at San Francisco State University, where he has taught since 1982. He completed his Ph.D. in Mathematics at the Polytechnic University of New York in 1972. He is the author of a textbook and numerous research articles in number theory, his field of specialization. The courses he has taught include the history of mathematics. He will be speaking about the history of Art, Math and Religion.

Mary Teetor, member of YLEM's Special Interest Group on Patterns, makes tessellating patterns in intricate embroidery, and labyrinth medallions in beadwork. She has a clever algorithm to invent new hexagonal labyrinth designs. She will be presenting material for a new book that she is working on.

YLEM Forum:
Wednesday, May 14, 7:30pm
Area 2881, Art Robotics Studio
2881 23rd St.
San Francisco, CA 94110
The audience is encouraged to arrive at 7 pm to socialize.

Come explore the art and inner workings of Area 2881, studio to Carl Pisaturo. Learn about reliable electrics, electric nervous systems and the mysteries of led pulsing strobe lights. Explore the processing and properties of materials like 2 part urethane polymers, belts, shafts and ball bearings, silicone elastomers and miniature wire rope.

Carl Pisaturo is an area artist, currently focused on operations in experimental aesthetics, focused on constructions thematically revolving around robotics, electronics and computer interfacing. He has built experimental objects exploring the human form, other organic formations, myth, other elements of popular culture. Carl earned a BA in Biology at Boston University, a BS in geology at UMASS, and as worked as an applications engineer for the Stanford department of Neurology.

Carl Pisaturno, "Orbit 450"

The Dichotomy of Reality, cont'd

understanding. At any instant the theories we have are the best we have at the time, they can't be otherwise, but they are subject to change without notice and as the history of science shows this happens time and time again.

I have attempted to explore some of these issues in my own recent digital artwork, particularly the notion of macro things emerging from micro conditions. The concept of consciousness arising from the zero-point field (or a yet to be defined all-integrating field) is a challenging and intriguing area of further research and artistic exploration.

I'd like to take this opportunity to thank all the contributors for their time in preparing their articles and for sharing their ideas with the YLEM community. I would also like to thank Loren Means for offering me the opportunity to guest edit this issue of *YLEM Journal*.

1 – Adler, S.L. *Quantum Theory as an Emergent Phenomenon* Cambridge 2004
2 – *New Scientist* pp.37-39 November 2007

AN ENTANGLED REALITY:
Quantum Theory and the Nature of Reality

C.S. Unnikrishnan
Gravitation Group/FI-Lab
Tata Institute of Fundamental Research, Mumbai
unni@tifr.res.in
www.tifr.res.in/~filab

Introduction

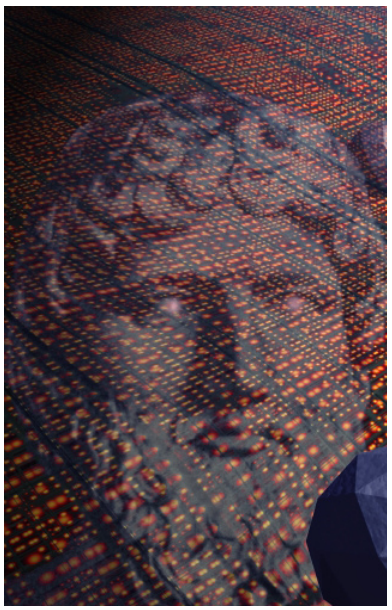
The theme of this article is the nature of reality in the context of understanding and representing the physical world from the point of view of quantum physics. The debates on reality have been unending and inclusive, but in the steps that make up the physical sciences it is irrelevant whether there is reality to the physical world beyond what is perceived or what is imaginable. It is only a belief in objective reality, in contrast to evidence, that seems to be needed in the physicists endeavor. In a way physicists avoid the realism debate. In the context of quantum physics, the relevant issue is the irreconcilable clash between our notions of classical reality and of quantum reality, and not the issue of objective reality of the physical world.

We may call the reality in physics of a world that is in principle perceptible, and therefore comprehensible, as the secondary reality, keeping the scope open for an underlying primary reality that we leave without characterizing or defining. Both the physical Universe and the physical laws exist in this layer of secondary reality. Our representation of this secondary reality involves further approximations and modeling, involving our human limitations of perception, cognition, and representation. Therefore, what we deal with finally in physics is a tertiary reality, existing in our theories and models. These change over time, and can in turn affect the elements in the secondary reality zone.

There are two ways in which the present physical theories operate in planes far removed from the plane of secondary reality. One is in the use of unobservables in physical theories. These include space and time, potentials, fields, wave-function, and many others. Another is the dichotomy between the fundamental theories and cosmology. All our standard theories were completed well before any serious knowledge about our Universe was acquired and verified. Thus, none of these theories incorporate in their structure the matter distribution in the Universe and its enormous gravity, which provide an absolute frame for space and time. An absolute frame in physics drastically affects our notion of the reality of the external world. Physical theories that do not incorporate the ever-present matter-filled Universe and the unavoidable cosmic gravity have their basis on an assumed reality that is not factual, and therefore are likely to be incomplete or incorrect. However, the theme of this article is not so much how far away the present day physics might be from what could be considered objective reality. Our theme is the clash between our notions of classical reality and quantum reality, and how physics is progressing in its track in more or less complete disregard for the issues of realism and ontology.

Unobservables in classical and quantum physics

Physical theories are supposed to be about the real observable world. Yet, they use several unobservables in their core structure. Space and time without any reference to matter are unobservables of a serious kind. Surprisingly, the Machian criticism of space without matter died down in the minds of modern physicists, in spite of its sharpness and depth. Now cosmologists talk about expanding space in the context of the Big Bang Universe, insisting on space expanding, with the galaxies fixed in their spatial positions, while denying that the galaxies might be in real motion. Unfortunately, they do not realize that there is nothing in the scientific method that allows them to insist on this view. Ascribing physical reality to space has allowed physicists to imagine that the 'real' physical world might even be of 9 dimensions, all but 3 curled up into ultra-small sizes that cannot be observed. These are speculations on shaky grounds, without proper attention to the fact that both space and time have no ontological meaning or stability without matter. It is conceivable that several problems that are usually debated in the context of quantum gravity, including the problem of time, will disappear as irrelevant once the inseparability between space-time and matter is understood and acknowledged .



Rob Harle,
"Plato's Ghost Haunts the Matrix
giclee print digital artwork"

The visible and invisible about light

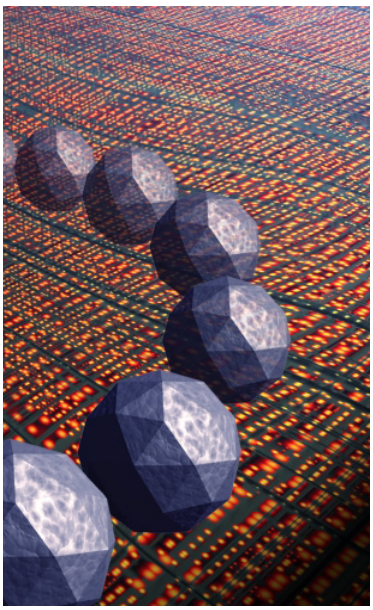
Most of the Universe is probed by light and electromagnetic radiation. But there is strong evidence that there is much more matter than what we can see in this Universe. The inferred amount of "dark matter" and "dark energy" is almost 20 times that of visible matter, and constitute about 95% of all matter. While these forms of matter arise in the attempt to reconcile limited, though careful, observations with what we can theorize at present, our standard theories force upon us forms of energy that are unimaginably larger in quantity than the hypothetical dark matter and energy. The zero-point energy associated with light and electromagnetic radiation (the quantum mechanical energy contained in the fields in a state in which there is no detectable light) is, theoretically, more than 10100 times what is consistent with our standard theory of cosmology and with observations. The Universe would be nonexistent today if even a small fraction of this energy were really present. Either there is some aspect that is seriously missing in our standard cosmological model and general relativity, or the apparently successful quantum theories of fields as we know and use today are incorrect at their very basis. Description of reality in terms of the unobservable fields that obey quantum theory has brought up a heavy invisible baggage that we cannot discard as an illusion, nor can we accept as real.

Quantum physics and the entangled (un)reality

Quantum theory suffers from a serious problem of ontology. The interpretation of the wave-function and of measurement is at the core of the problem. The physical state of a quantum system, like an electron or an atom, described by a "wave-function" is at present just too abstract to be grasped in terms of any

familiar element of reality. Yet it represents, when multiplied by itself, the statistical probabilities of various random results obtainable while observing a quantum system. The unobservable wave-function can, however, be affected by mirrors and magnetic fields and by devices we feel and handle in space, yet there is nothing in the theory that suggests any physical reality to the wave-function. In fact, the theory is not able to sustain an interpretation where the physical system always exists in some definite physical state, whether or not one has observed it. There are situations involving more than one particle, called entanglement, where each individual particle has no physical state at all! The reality of quantum description is not perceptible even to the inner eye.

This can be illustrated with the case of an atom consisting of a proton and an electron breaking up, and the particles moving in opposite directions. Both the proton and the electron have equal spin, in opposite directions, if we consider the case when the initial atom had the total spin zero. Essentially all of physics operate with some primeval conservation laws controlling the dynamics and kinematics. Conservation of energy is one of these, and so is the conservation of angular momentum. In any case, in our familiar thinking and visualization, the individual electron and the proton should have opposite spins even after breaking up, and the proton spin will be in some direction in space, and the electron spin will be in a direction opposite to that. Therefore, each particle is expected to have some, though unknown, state of spinning, with the only constraint that they should be opposite. This simple classical expectation about a perceptible and reasonable physical world is shattered completely in the quantum description. It does not allow any way of description where each particle is in some (whatever) unknown state of spinning — the two together will have zero spin alright, but each does not have any state of spinning at all separately! The entangled state represents a situation where the total system has a definite quantum mechanical state, but the individual particles, though they can be observed separately, do not possess some unknown state of existence. The theory proposes actualization or physicalization of the spin direction for each particle only when a measurement is made. Once one of them is actualized by observation, the other has to spontaneously actualize into the opposite state, and this is what is termed a nonlocal collapse in the theoretical description. It is important to realize that this superluminal nonlocality happens in our effort to causally visualize, in classical terms, what happens in space and time, going beyond the theory, and there is no empirical evidence for or against any nonlocal influence between the two particles, contrary to popular statements while describing such phenomena. That is, there is no evidence whatsoever for any causal connection between the act of measurement on one particle and the result of measurement on the other. Perhaps it is important to explain this in some more detail.



Quantum theory has no space-time ontology, and it associates physical states with abstract vectors in an abstract mathematical space. The most important feature in the theory is that the representation of a valid physical state can be a "superposition" of representations of other valid physical states —a drastic departure from the classical physics of particles. However, superposition is a concept familiar in the classical physics of waves. All predictions in quantum theory are statistical. But there is clear indication of wave and particle concepts mixing together in an intimate way. The statistical content of the theory has no causal explanation whatsoever. One might attempt to construct a causal statistical theory, along the lines of classical statistics of random events, but without incorporating the aspects of wave-particle duality, as done in Local Hidden Variable Theories (LHVT) considered by John Bell and others in the sixties. These are classical theories with locality, like theories of coin tossing, dealing with discrete quantized values of observables. Analysis of such LHVTs predicts correlation functions for multi-particle systems that are limited to some definite upper bound, called the Bell's inequality. There are many situations realizable in experiments where the correlation predicted by quantum mechanics exceeds this bound, and violate the inequalities. Experiments also show correlations that violate the inequalities, in the sense that the measured correlations exceed the bound in Bell's inequalities. Thus, experiments are consistent with quantum theory, and violate Bell's bound. However, one can change the assumptions that went into the derivation of the Bell's inequality, and propose a new HVT without locality, for example — a classical statistical theory that has superluminal nonlocal influences passing over large distances — and such a theory can also be consistent with experimental results. Indeed, the logical implication of the violation of the Bell's inequalities is not that there is nonlocality in this world, but that a classical statistical theory, different from quantum theory, could be the correct theory of correlations if faster than light nonlocal influences are allowed. The experiments in any case do not suggest the existence of superluminal signals between quantum physical systems. It is causal interpretation of the results of the experiments — a free human creation of imaginary reality — that contains nonlocality.

These statements are further strengthened by my recent proof that the correlation functions derived assuming only the validity of the fundamental conservation laws, without subscribing to any particular theory, agrees with the experiments and also with quantum theory . Therefore LHVTs are theories that are incompatible with fundamental conservation laws of physics; they are flawed in their core, and hence are not worth testing. Clearly, there is a serious clash between our picture of the quantum reality, and what could actually be the microscopic reality in the sense of secondary reality. On the one side there is one reality of our theoretical representation of the microscopic world containing electrons, atoms and light with spin and other familiar properties, the tertiary reality of quantum theory, and on the other side there is another tertiary reality evolved from our familiarity with the physics of the macroscopic world of

spinning balls and celestial objects. These clash, and no attempt to reconcile the two have succeeded.

In the initial days of quantum theory Bohr could bully his associates and critics, except Einstein, into being satisfied with a consistency that was brought about by proposing that there are things in this world, called classical apparatus for observation and measurement, to which the rules of quantum mechanics do not apply. If observation is the only method of actualizing a definite physical state, the observing device itself should not be quantum mechanical. This stand contains a built-in inconsistency of a dual world and of dual laws, but there has been no satisfactory solution to this inconsistency. General claims that the idea of decoherence — or the dissolution of definite wave-like phase relations between different possibilities of physical realizations — solves the problem are incorrect, since decoherence deals with an ensemble of systems, whereas we are discussing a problem of the physical state of a single system. If all objects in this world are quantum mechanical, in the sense of being subject to the rules of quantum mechanics, then each interaction brings up a layer of entanglement and inseparability — the observed and the observer together have a definite quantum state - but neither individually is in any representable physical state. Individual objects lose the individuality of their physical state, and eventually no real physical state can be actualized by any object. This has been exemplified in Schrödinger's description of the entanglement of the state of a macroscopic cat with that of a microscopic quantum system. After the interaction the cat has no physical state (the common statements that the Schrödinger's cat is in a state of "being dead and alive simultaneously" are incorrect and misleading). Finally, the observation that resolves the state of the cat, and of the atom, is to be done by some device or being that is "outside the scope of quantum entanglement," and hence classical. Attempts to remove this infinite regress by proposing that somehow human consciousness as the final and ultimate observer will imply that consciousness itself does not obey the rules of quantum mechanics in spite of being a higher level emergent phenomenon with its basis in matter, as physicists like to believe! In short there is at present no way of explaining how a definite physical state is realized during an observation, without denying the general applicability of quantum theory.

New directions

Is there a way to go beyond the standard quantum theory in an attempt to resolve these problems? One thing that is clear to me is that when these issues are solved, they will be solved in a bundle, in one go. Quantum theory has been extremely successful in its statistical predictions, and all the problems we discussed have to do with its structure that allows the superposition of the representations of physical states. Hence, a solution for just one of the issues (reality or locality issues) without satisfactory solution to the rest (actualization of a physical state during measurement, the physical cause behind the statistical spread of measurement results etc.) is unlikely to be complete. It is also clear to me that re-interpreting the same mathematical machinery will not lead to a more satisfactory theory. Different interpretations of the quantum theory merely trade one serious problem for another equally or more serious one, without solving the real issues.

One of the research lines we are pursuing at present attempts to relate the phase of the quantum state, a wave-like aspect, to the peculiarities of quantum behavior — perhaps not radical enough, but encouraging in its first results. The idea is that all the random statistical aspects of quantum theory might arise in this degree of freedom that already exists in the formalism, but unutilized in the discussion of fundamental problems. This suggestion seems to have some truth in it, since it is easily possible to have a quantum system with two particles, each of which individually have random phases in their states, but their relative phase is fixed for every pair as they are generated. This can give rise to random results for the measurements on individual particles, and perfect correlations for joint measurements, as seen in experiments, without any nonlocal influences. This approach can restore reality, albeit at a level hidden from human observation, since absolute phases are unobservable. This is far more satisfying than the present situation where there is not even an imaginable reality in quantum mechanics. It is as if we lift up and disentangle the overlapping and unresolved quantum problems by adding another dimension involving a familiar concept of reality. Whether or not this approach resolves all the problems satisfactorily remains to be seen.

References

C. S. Unnikrishnan, "Role of Unobservables in Physics," in the *Proceedings of the International Conference Science and Beyond* (Eds. S. Menon, B. V. Sreekantan, A. Sinha, P. Clayton and R. Narasimha, NIAS, 2003); Contemplations on our physical links to the universe, LEONARDO (MIT Press) 39, 71-75 (2006).

C. S. Unnikrishnan, "Cosmic Relativity: The Only Consistent Ontological Foundation for theTheory of Space-Time and Relativity," to appear in the PHISPC Volume on History of Science and Philosophy of Science (edited by B. V. Sreekantan) 2008; *Cosmic Relativity: the Theory, Predictions and Experimental Tests*, gr-qc//0406023 (2006).

C. S. Unnikrishnan, ibid.

E. Mach, *The Science of Mechanics*, pp 277-306 (The Open Court Publishing Co. London, 1942).

C. S. Unnikrishnan, "Quantum Gravity and the Structure of Physical Reality," in PHISPC Volume XIII, Part 6 on *History of Science and Philosophy of Science* (edited by P. K. Sengupta) 2008.

C. S. Unnikrishnan, "Conservation laws, Correlations functions and Bell's inequalities," *Europhys*. Lett. 69, 489- 495 (2005); "The incompatibility between local hidden variable theories and the fundamental conservation laws," *Pramana* – Jl. Phys. 65, 359-379 (2005).

C. S. Unnikrishnan, "Schrodinger's cat: Myth, Physics and Philosophy," Sandhaan (Jl. Of Indian Council of Philosophical Research), Vol. V, pp 1-52, (2005); also to appear in PHISPC Volume XIII, Part 6 on *History of Science and Philosophy of Science* (edited by Prof. P. K. Sengupta) 2008.

C. S. Unnikrishnan, "Resolution of nonlocality puzzle in EPR paradox," *Current Science* 79, 195-201 (2000).

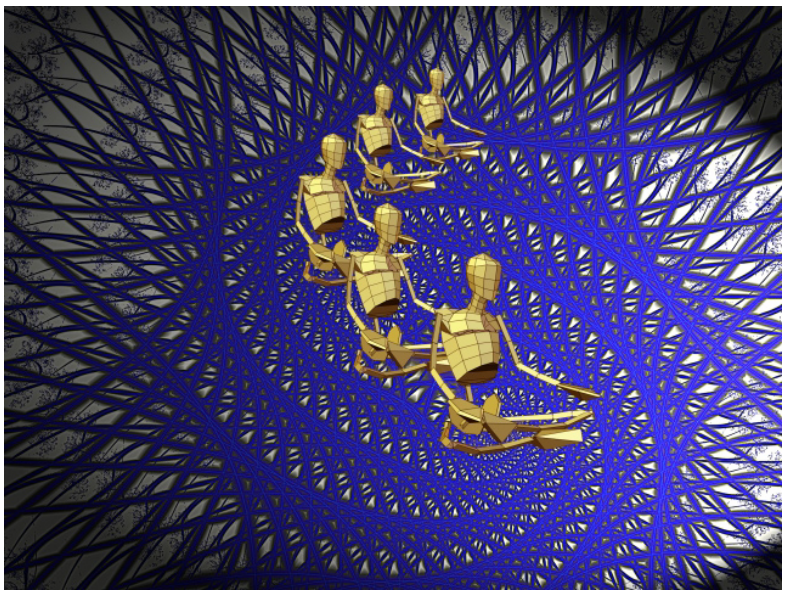
C. S. Unnikrishnan, ibid; "Is the quantum mechanical description of physical reality complete? Resolution of the EPR puzzle," *Found*. Phys. Lett. 15, 1-25 (2002).

THE ART OF QUANTUM HEALING

Dr. Jacqueline Boustany MBBS (Hons.), Dip Paeds, MPH
jboustany13@hotmail.com

I invite all of you interested in health and wellbeing to join me for a brief exploration into the world of quantum physics, energy medicine, and how that relates to the effect of emotion in the body. Biophysics gives us a visionary view point, if only a reminder that ultimately we are resonant, feeling beings, energy expressing and experiencing ourselves in matter.

Quantum physicians describe matter as condensed vibration or frozen light, like condensation of steam into water and eventually ice, as the molecules are progressively slowed. This also highlights how matter is affected by its environment. In fact everything we see is part of a continuous field of electromagnetic charge (1), and what our senses are actually picking up, is the difference between vibratory frequencies (2). The brain is really a processing and retrieval unit of the "zero-point field"(1), talking to itself and the rest of the body in the language of wave interference called Fourier patterns, projecting a holographic impression of its experience within the body (3). It filters this information based on previous experience, called the Law of Association, so we are not overwhelmed by the volume and rate of information or diverse incongruities, but this may also filter information not able to fit in the established neuronal pattern or Neuronet. You literally will only see what you already think to be real, unless you have a neuronal net that allows for other possibilities (3).



Rob Harle
"Meditation in Curved Space"
giclee print digital artwork

The mind is not just the brain, as various studies with memory retained after resecting parts of and ultimately mincing the brains of mice and salamanders have discovered (1). It is the whole body experience of our own field of influence within the broader consciousness (4). At any point in the body-mind, two things come together: information, in the form of energy imprints, and matter, as Einstein's equation of $E = MC^2$ remains in equilibrium (5). Every cell is perceiving and responding to its environment via the receptors on the cell wall. These are communicating via structures within and without the cell, such as crystalline microtubules also influenced by their environment, such as the effect of posture on mood (6).

An example of this is the effect of emotion in the body. As we have a thought, (more often unconscious than conscious, which makes things difficult to track), a physical chemical reaction matches that thought (7). The effect of this chemical cascade is not just felt by one part of the body, it's a whole body experience, like the adrenaline feeling of fear preparing the body to "fight or flight." As this reaction is meant to be a matter of life or death, and thus happens in less than a third of a second, it is actually statistically impossible for this reaction to follow the traditional "lock and key" hormone theory, where the hypothalamus — pituitary gland sends a message to the adrenal glands to release adrenaline to affect other cells.

Fear, or any other emotion, chemical or nutrient, has its own signature frequency, which changes the electrical charge of the cell to have a certain reaction, depending on the cell's homeostatic vibration (8). The immune system might react to the message differently from the hormonal system, depending on what part of the radio band they are tuned into. E-motion is thought energy in motion, holographically imprinted as chemicals in the body transmitting energetic information (7). Different emotions have been categorized into different frequencies; shame, guilt and fear have slower vibrations and peace, love and forgiveness are at the faster end of the scale (8). This vibration affects the coiled DNA superconductor, transmuted by surrounding water molecules, causing it to tighten or expand respectively, affecting amongst other things genetic program expression, mitochondrial function and protein production (8).

Sublimation of emotional states like shame, fear or grief could be the basis of dis-ease or even ageing, as they slow DNA and mitochondrial drive and limit the production of essential elements. When emotions are not openly acknowledged, often because they are unacceptable to the conscious mind because of previous experience or the current cultural environment (10), they are held in the body as a vibration sometimes called an "emotional cyst" (7). This slows down the flow of information, micro-circulation and perineural healing to those cells, thereby affecting cellular function and communication (8). Suppressed stress has been linked to suppression of the immune system, for example, allowing infection to take hold (11) or the cell may not receive normal growth inhibition signals from its environment, a theory of cancer creation (12). Defensive emotions such as anger, that is, failed suppression of grief or fear, are repeatedly linked to cancer, heart disease, gastric ulcers, migraine, hypertension, autoimmune disease and neuro-inflammatory syndromes such as mania or schizophrenia (13, 14).

Unmet emotional needs: a) unconsciously drive health-related behaviors such as drug-taking, poor eating choices or even

driving fast, b) act directly on pathophysiological pathways; and c) mediate responses to assistance, as people may not believe they are worthy of assistance. Much of this information is not taught to the practicing health community and continued suppression of our natural emotional experience by any short-term, purely symptom relieving method, including medication dependence, perpetuates mental and physical illness in our culture (5). We use these things to survive in an environment increasingly filled with fear and old inherited, untrue belief systems that are unconsciously passed down by our forefathers. Beliefs such as "I am not enough" or "there isn't enough" can be assessed using cognitive awareness techniques such as The Work (15), once they are allowed to literally come to the surface of consciousness.

Scientific knowledge not withstanding, it is easier to experience this for yourself. Next time an acute emotional reaction presents itself, feel into your body for where it is centered. No one else can really understand it like you do, for a start, and it's often not the emotion that's the problem, but our struggle with it, our denial of it to save face, to cope in the way we have been taught by shoving it down further. All emotion has a physiological reason for our survival; anger may indicate protective boundaries have been crossed or fear allows us to be on alert. The body doesn't know the difference between real and imagined fear, but the conscious mind can help, listening to it as you would an emotional child, validating your right to have a normal reaction, reassuring it of its worth and thereby providing its needs in an ultimately self-sustaining way. This part of you will also help you in your journey, as this is where the juice of creativity, innate knowing and dreams of your passions are also held.

Be aware, however, that the resistance to admitting your humanity has been unconsciously trained in us, like a man not being allowed to cry. This resistance is often sourced from repeated maladaption learnt in childhood. As children we depend on nutrients and energy given by our carers. Without attention and love we may even stop growing physically (5). If we are cared for by people who don't feel safe to cry or scream or sit with their own pain, they will seek to suppress this expression and we will do whatever it takes to survive, and so the cycle continues. In terms of Emotional Intelligence, we may still be children, having shut off our own emotional growth. Erickson (1974) described critical stages of personality development where the individual would have the opportunity to learn key concepts such as trust in the first year and autonomy in toddlerhood. Without a safe environment for emotional expression, the concept may not be learnt and problems with that issue will continue to arise in later life. It is said that 70% of issues in childhood occur in the first 7 years of life, a further 20% in the second 7 years. If these issues remain suppressed, they will project holographically in the person's life until the concept is learnt (16). This is why someone who may have mastered one section of their life may still behave illogically in another. In addition we are parenting in isolation, as our elders and their wisdom have been removed to retirement villages and many of the rituals of initiation into adulthood have been lost to history.

We can easily understand then how internal dis-ease is related to external dis-ease in our family, social and political units. Whole cultures continue to carry unresolved trauma and limited belief systems, reflected in the continuing disharmony of our power structures, being ultimately made up of fragile, disconnected human beings. It is said that at the core of every human being is the need to love and be loved. Emotional mastery is knowing and parenting our whole selves without judgment, which leads to self-empowerment, success, good health and ultimately a happier, healthier society (17). Connecting to others on this basic human level ensures equality, compassion and clear communication as we re-establish our relationship to the earth, our community and our higher selves.

Quantum physics describes the universe as holographic, just as the cells are a reflection of our mind (8). Everything we see outside of ourselves is within us, and whether we judge our experience as good or bad is a matter of perspective. Our one chance at true empowerment and liberation is to be able to sit with all these aspects of ourselves, without judgment, learn from them, and thus transcend them. That way we can see the good in the bad and no longer be controlled by unconscious reaction or illusion. The ultimate illusion described by centuries of sage wisdom is that of separation and the ultimate truth coming to the fore in quantum physics is that this is impossible. Whether it is String Theory or Loop Theory, the evidence of non-locality describes the connection of everything to everything else in the universe simultaneously. We are as much a part of the energy of life as any flower, chemical or quark, and it is our birth-right to live this truth.

References

1) The Field, L.McTaggart, Harper Collins 2003 .
2) Vibrational Medicine, R Gerber, Bear & Co 2001.
3) The Holographic Universe, M. Talbot, Harper Collins 1996.
4) The Quantum Doctor, A. Goswami, Hampton Roads 2004.
5) Quantum Healing, D. Chopra, Bantam Books 1990.
6) Energy Medicine-The Scientific Basis, J. Oschman, Churchill Livingstone 2001.
7) Molecules of Emotion, C. Pert, Touchstone 1997.
8) The Biology of Belief, B. Lipton, Spirit Inc. 2000.
9) Power vs Force- An Anatomy of Consciousness, D. Hawkins, Hay House 1998.
10) The MindBody Prescription, J. Sarno, Warner Books 1999.
11) Love & Survival, D. Ornish, Harper Collins 1998.
12) The Dark Side of the Brain, H. Oldfield + R Coghill, Element Books 1998.
13) Vitaliano P. et al (2002): "A Path Model of Chronic Stress, the Metabolic Syndrome, and Coronary Heart Disease." *Psychosom Med*, Vol 64(3): 418-435.
14) Cytokines and Cognition "The Case for a Head-to-Toe Inflammatory Paradigm." *J. Am Geriatric Soc,* Vol 50 (12): 2041-56.
15) Loving What Is, Byron Katie, Random House 2003.
16) The Holotropic Mind, S Grof, Harper Collins 1995.
17) Emotional Intelligence, D Goleman, Bloomsbury 1996.

TOWARDS QUANTUM SCULPTURE

Julian Voss-Andrae (artist/scientist)
julianvossandrae@hotmail.com
www.julianvossandrae.com

The classical view of matter.
We consist of matter and so does everything around us. The history of science reveals that our conception of matter is of fundamental importance to our world view. The modern view of matter emerged during the Renaissance, culminating in Newton's theories of mechanics and gravity. In that framework, each portion of matter is viewed as possessing a well-defined path through space, a trajectory consisting of a certain location for every point in time. Many aspects of the physical world could be explained convincingly within the Newtonian framework, such as thermodynamics, acoustics, or celestial mechanics, which led to great confidence in the theory. One strange aspect of the theory was that all trajectories are precisely determined for all times and therefore completely predictable by a given set of initial conditions, such as a particle's position in space together with its velocity, which seems at odds with our impression of possessing free will.

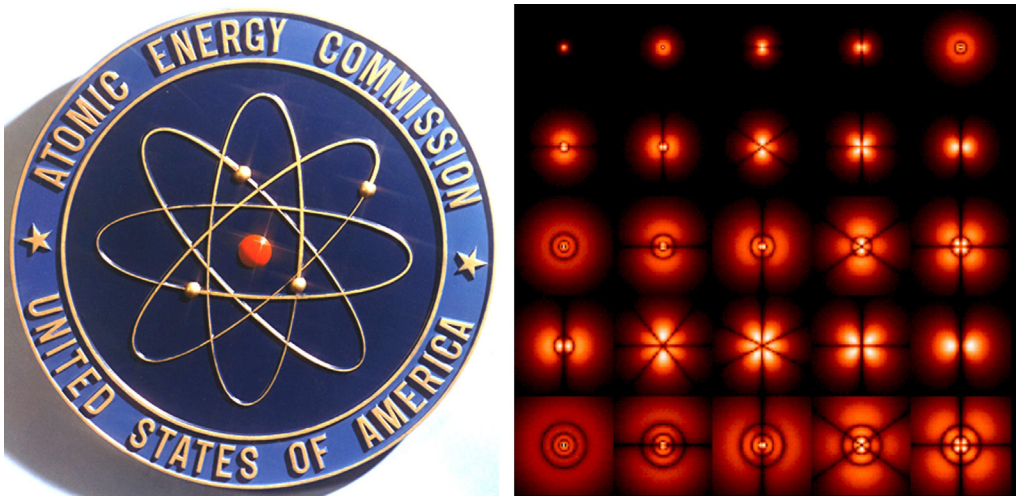


Fig. 1.
The left panel shows a cartoon image of an atom with the electrons orbiting the nucleus. The right panel shows calculated electron probability densities for an atom in different states of excitation. This particular example is of hydrogen, the smallest atom. Atoms of the other elements look very similar.

An unquestioned aspect of matter was its perceived continuity. Matter was never seen to suddenly disappear and reappear. Similarly, matter was viewed as possessing an unequivocal identity: Portions of matter were assumed to either be separate or to be touching each other, but not to be penetrating each other. Matter was generally assumed as being confined by well-defined boundaries.

The quantum view of matter:What does an atom look like?
The building blocks of most matter we encounter are atoms. Single atoms look and feel very different than the bigger portions of matter they make up. First of all, atoms do not 'look like' in the literal sense of the word, because they are much smaller than the size of light waves and therefore invisible. Only objects bigger than the wavelength of light — a few hundred nanometers — reflect light back into our eyes or microscopes, and the electrons even of a big atom have no significant chance of detection farther than a nanometer away from the nucleus, so it is just too small to be seen. It is instructional to see how atoms do not look like — the left side of Fig. 1 gives a typical example of such a cartoon image of an atom.

The most misleading aspect about this kind of imagery are the planet-style ellipses that are a standard feature of such images. In truth, the electrons are quantum objects. That means as long as they are not detected, they simply do not possess a precise location, and therefore the whole concept of a trajectory becomes meaningless. The physicist says, "The electron is not localized."

What the electrons possess before detection is merely a likelihood to be found somewhere. An interesting aspect about this probability density, as this likelihood is called, is that it is typically a smooth function smeared out in space. So even though we cannot use light to create an image of an atom, we are still able to draw a meaningful picture of the "electron cloud" by visualizing the calculated or measured probability density that tells us the likelihood of finding the atom's electrons. The right panel of Fig. 1 shows such images. This particular probability density was calculated on the computer, but there is no reason to believe that it would look differently if obtained experimentally.

A quick glance at the fuzzy images already illustrates one important aspect that holds true in the whole (quantum) world - things ultimately do not have a hard edge or some sort of well-defined boundary where one thing ends and another one starts. In reality, assigning objects an individuality based on such a boundary is not more than a convenient approximation. When we measure exactly where the electron is, we will detect it only at one specific spot within the region of significant probability density. If we repeat this same measurement we will probably detect the electron at a different spot, but on average more often in the lighter colored regions and less often in the darker regions. After many repetitions of the experiment, the smooth and fuzzy character of the probability density will manifest itself by approaching the theoretical prediction as drawn in the images ever more closely, but the single measurement is never exactly predictable. So what determines exactly where we will detect the electron in a single experiment? The answer was famously shocking to Einstein, since it is "nothing": The location of the electron is not determined by anything, it is genuinely random. And that lack of knowledge does not reflect, as initially thought, a shortcoming of quantum theory. It is, on the contrary, a crucial aspect of it. It has been demonstrated convincingly that the mere assumption of the existence of "hidden variables" somehow encoding information about the exact location where the electron will be detected contradicts the ex-

perimental results. This breakdown of strict causality highlights the second important aspect of the quantum world - the world is ultimately non-deterministic, or, to put it differently, some things do happen without a cause. One nice implication of this finding is that it gives us new hope regarding our free will.

Monument to Chomp

In 2003, while I attended art college after having switched careers from physics to art, I was contemplating how the ideas encountered in quantum physics could be reflected in sculpture. A first connection occurred to me unexpectedly while I built a fence to protect a vegetable patch from our highly energetic border collie, Scout. The dog grabbed one of the posts and immediately attacked it with a relentless staccato of vigorous bites. Right before Scout managed to break the stick I took it back quickly. After coating it with lacquer and mounting it to a steel base I displayed it as (my own) art, shown in Fig. 2. The many irregular and un-aimed dog bites have narrowed the stick fairly regularly around the middle and because the dog needed to balance the stick horizontally in his snout, the likelihood of getting hit by his teeth was highest around the middle of the stick. This process reminded me of the build-up of a well-defined and regular electron density distribution out of many single stochastic events, as discussed above.

At the same time the dog made the stick fuzzy by chewing up the surface symbolizing the decay of the precise boundary in quantum physics as mentioned above. Although the "Monument to Chomp" was initiated with humor, it contains several aspects that I find intriguing in the context of quantum sculpture. Another aspect of importance in the history of sculpture and related to quantum theory, is the visual and conceptual tension between the 'constructive' (as in 'geometric' or mathematically simple) shape of the lumber and the 'organic' decay of the simple form [1].

Moving quantum objects and the double-slit experiment

So far we have looked only at a stationary system like the electron probability density around an atom's nucleus. Even though the electrons of an atom are in motion in the sense that, upon detection, they are found to possess a certain velocity, their distribution as a whole does not change. Let us now look at moving quantum objects, like a flying atom or cluster of atoms.

The trajectory of its point-like center of gravity is the classical description of a moving object. In quantum physics, the abstraction of the point expands into a fuzzy cloud. Instead of the classical "the object is exactly here" we have to be content with a likelihood to find the object in the vicinity of the classical center of mass. Again all we can know is a statistical law but one that is known to be obeyed very precisely.

But the movement adds another quality, a third important aspect of the quantum world mentioned here — the description of the particle has the features of a moving wave with wave fronts running perpendicular to the direction of its motion.

Fig. 2.
"Monument to Chomp" (2003) by Julian Voss-Andreae. Wood and steel, height 3-ft (90-cm). (© Julian Voss-Andreae) The right panel shows a detail.

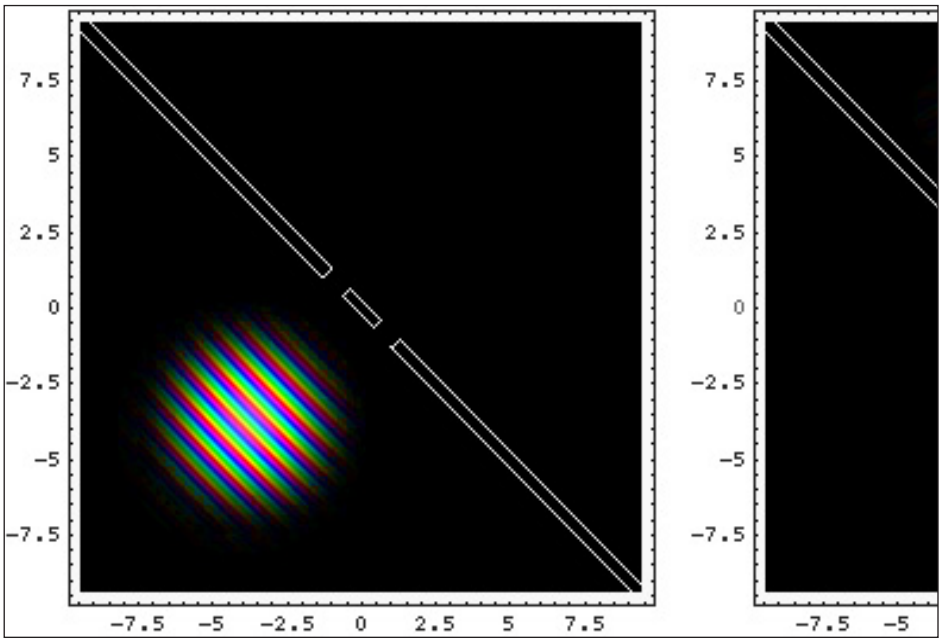
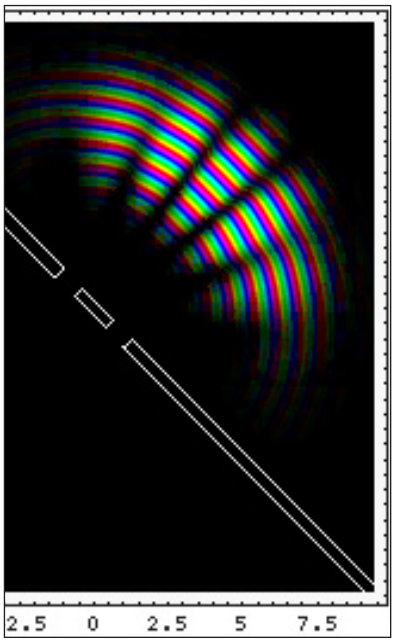


Fig. 3.
Computer simulation of the double-slit experiment from "Visual Quantum Mechanics" [5, 6]. (<c> Bernd Thaller) The quantum object approaches the two openings from the lower left corner (left panel) and splits up into several distinct regions of a significant likelihood to be detected (right panel). The detector (not shown) would be located in the upper right corner. The lighter the image the higher the likelihood to find the particle. The stripes are the wave fronts.

A very nice way of visualizing the dynamics of those complex wave functions was introduced by Austrian physicist Bernd Thaller in his book *Visual Quantum Mechanics* [2]. His website has some examples of moving quantum objects, for example a simulation of the famous "double-slit experiment" (see [3] and Fig. 3). This experiment is so well-known because, despite its conceptual simplicity, it already highlights all the problems we encounter in interpreting quantum theory. A quantum object (be it a particle of light or of matter) is sent flying towards a screen with two openings and, after passing through these slits, it is detected at a distance behind the screen. Of experimental interest is the distribution of particles hitting the detector

because it is quite different from what is expected if the objects behaved classically (such as balls or bullets would). Instead of detecting what is classically expected, namely two light bands stemming from the two slits, the particles actually display a pattern with not just two but several light and dark bands. The reason lies in the wave nature of quantum objects. The initial wave gets split up into two wave trains. Right after the screen they are still separate, but farther back they start overlapping and show, just like water waves, areas where the two waves cancel each other out (dark) and others where they add up (light), depending if they are out of phase or in phase in that direction. This light-dark pattern, known as an interference pattern, is the tell-tale signature of a wave. Furthermore, it also shows that this wave went through both openings simultaneously, since both wave trains are needed for interference. Were we to block one of the slits, this interference pattern would disappear.

The problem becomes clear when we now equate a portion of matter, say a single atom, with such a wave, as quantum mechanics demands. If we perform the experiment only once we are not able to tell if the position of the detected atom makes up an interference pattern. Therefore we repeat the experiment many times over, sending one atom after the other through the setup. It turns out that each atom contributes individually to the successive build-up of the same interference pattern. The more atoms we detect, the clearer the pattern becomes, again approaching the quantum mechanically predicted interference pattern ever more closely. So we have the extraordinary situation that something we usually experience as a single, indivisible particle went through two openings at the same time! This is the kind of problem we encounter when trying to make a single coherent mental image of quantum phenomena and it is just as puzzling today as it was in the early twentieth century, when quantum physics was discovered.



A buckyball is a particle is a wave

My graduate work in physics was concerned with a modern extension of the double-slit experiment. The double-slit experiment was devised and first conducted in 1802 with light, establishing the wave-like aspects of its nature. In 1927 and the ensuing few years, similar experiments with ever larger portions of matter were performed for the first time [4]. Extending such experiments to particles of larger mass is of deep interest since it allows shedding light on one of the most important problems in physics, namely how and why the transition from quantum physics to classical physics occurs. Since for fundamental physical reasons heavier particles require a smaller distance between the two slits in order for their interference pattern to be seen, larger masses could not be probed for a long time. It took almost 70 years until, thanks to microchip technology, sufficiently small devices could be manufactured to extend the old double-slit experiment to much larger particles.

I joined Anton Zeilinger's research group [6] in Vienna in 1999 to participate in an experiment probing the then by far heaviest particles ever in a double-slit type of experiment. The particle we used was a beautiful molecule with the odd name buckminsterfullerene, consisting of sixty carbon atoms arranged in the shape of a soccer ball. The buckyballs (as they are often called affectionately) were shot through 10ft (3m) of vacuum with a microfabricated grating in the middle serving as the double-slit. The openings were about 50 nanometer wide and twice that much apart from each other. Scaling up the proportions of the experiment into our size regime (with the 1-nanometer-diameter buckyball assumed as having the size of a soccer ball), the slits would have the width of ordinary soccer goals but the kicker standing on earth would have to shoot the ball to the moon. In summer 1999 we saw the first interference pattern, confirming that even such comparatively large particles indeed display quantum behavior [7].

Buckyball sculptures

Inspired by Leonardo's 1509 drawing of a truncated icosahedron [8] (as the buckyball is known to mathematicians) for a renaissance mathematics textbook, I welded my first buckyball from sheet bronze in 2004. I noticed that the windows in each facet provide the material for another, smaller buckyball. I reiterated this procedure, thereby creating a succession of four buckyballs. I placed the buckyballs inside each other, attaching them in place by running thin rods radially through the sixty vertices (see Fig. 4). It is appealing to me in that context that the nested structure echoes the repetitive structure of a spherical wave, emanating from a central source. In addition to that it seems the open, air-filled structure of the piece is especially suited to convey the ephemeral nature of a quantum object.

This aspect of creating a sculptural object consisting of comparatively little material while occupying a considerable volume of space interested me because it is a natural way to create a metaphor for the quantum nature of matter. I started making larger buckyballs from steel consisting only of the edges, culminating in a piece fabricated from 2in (5cm) round tubing with a diameter of 30ft (9m) that I first installed in 2006. Now permanently installed in a park-like setting in Portland, the buckyball is suspended in the air above arm's reach over a sloped terrain with a small creek running under it. Three very large and straight Douglas firs arranged in a fairly regular triangle are growing through the structure echoing the symmetry of the buckyball. The orientation of the buckyball is chosen such that two opposite hexagons, one at the bottom and one on the top, are lying between the trees on horizontal planes.

The main reason that such a basic shape succeeds as a piece of art is its placement within nature. Despite the considerable size, the buckyball's visual impact is quite subtle due to the relative thinness of the tubing and the natural color of the corroding steel. The trees intersecting the buckyball dissolve the mathematical shape, symbolizing quantum physics' revelation that matter has no clear-cut boundary. On a more general level, the

installation is concerned with the dichotomy between nature, symbolized by the trees, and culture, represented by the mathematical shape. Reading the sculpture and its surroundings this way, culture hovers between the poles of embracing nature and caging her.

Quantum Man.
My former boss Anton Zeilinger once remarked jokingly that the fact that the wavelength of a walking human happens to be approximately the Planck length [9] cannot possibly be a coincidence. This comment made me think of how such a wave function would look and a few years later I created a sculpture inspired by this idea. Using pieces of steel sheet arranged parallel and constantly spaced to represent the wave fronts, I modeled the shape of a stylized human walker (see cover image). I welded short pieces of steel rod irregularly positioned

Fig. 4.
"Quantum Buckyball" (2004) by Julian Voss-Andreae. Fabricated bronze, diameter 2-ft (60-cm). (© Julian Voss-Andreae)

to connect the slabs. The combination of the regularly spaced slices with the irregularly positioned connecting rods evokes associations with stochastic events and, more concretely, with the formulation of quantum mechanics in terms of Feynman's path integrals, a mathematical tool for calculating quantum mechanical probabilities by adding up all possible ways by slicing up time to parameterize arbitrary paths. After finishing I noticed the most striking aspect of the piece — when approached from the front or back, the sculpture seems to consist of solid steel, but when seen from the side it dissolves into almost nothing. The sculpture's appearance changes drastically with a small shift of the viewer's perspective. This effect provides a striking metaphor of the dual nature of matter with the appearance of classical reality on the surface and cloudy quantum behavior underneath [10].

Conclusion.
I believe that the advent of quantum physics in the sciences and the rise of modernism in the arts represent two facets of the same profound shift in the evolution of humankind. The uneasiness we tend to experience when dealing with either illustrates how little we have grappled yet with the consequences of this paradigm shift, comparable in depth to the renaissance. The works presented in this paper try to help explore the character of this shift and make it part of our collective consciousness by taking it out of the isolation of the intellectual realm into the sphere of sensual experience.

This essay is based on a talk given at Wonderfest 2006 at UC Berkeley and Stanford University.

References and Notes

1. J. Voss-Andreae, "Protein Sculptures: Life's Building Blocks Inspire Art," *Leonardo 38* (2005), pp. 41—45. (2005); <http://julianvossandreae.com/Work/LeonardoArticle/LeonardoArticle.html>
2. Bernd Thaller, *Visual Quantum Mechanics* (New York, Heidelberg: Springer-Verlag, 2000).
3. Bernd Thaller, Visual Quantum Mechanics website <http://vqm.uni-graz.at/>. For the discussed movie, click on "Movies", "Samples from Visual Quantum Mechanics", and "Double-slit experiment".
4. The particles probed where electrons, atoms and even a small molecule (H2). For references see [5].
5. Julian Voss-Andreae, "Kohärente Molekülоptik mit Fullerenen," Diplomarbeit (Berlin: Freie Universität Berlin, 2000). <http://julianvossandreae.com/Work/diplomathesis/Diplomarbeit.pdf>
6. The main page of Anton Zeilinger's group can be found at <http://www.quantum.at>.
7. Markus Arndt, Olaf Nairz, Julian Voss-Andreae, Claudia Keller, Gerbrandt van der Zouw and Anton Zeilinger, "Wave-Particle Duality of C60 Molecules," *Nature 401* (1999) pp. 680—682. <http://julianvossandreae.com/Work/C60article/c60article.pdf>
8. See for example image 2.2 on p. 6 of [5].
9. The Planck length is very small distance of 1.6 x 10-35 m, presumably of fundamental meaning in physics. The Planck length and similar units derive very simply from the three major constants c, and G.
10. "Dual Nature," Science 313 (2006) p. 913. <http://www.JulianVossAndreae.com/Artist/resume/images/2006_08_18_Science.html>

LEIGH ARNOLD: EVOLUTION OF A DYSLECTIC

Dr. Len Martin
pteropus42@smartchat.net.au

Paradox 1 That a biologist who counts himself a mathematical idiot is writing about an artist whose work is used by the Australian Mathematical Sciences Institute to advertise Concepts of Entropy and their Applications and Symmetries and Stability, and in whose work mathematicians discern, "interesting meta-mathematical structures... subtle departures... and... violent cascades away from symmetry, as in bifurcations of dynamical systems and spontaneous symmetry breaking in cosmology... linear code sequences, with... randomness expressed by striking changes of color and orientation." (1)

Paradox 2 That this article is for a journal for "artists using science and technology", when Leigh Arnold uses only brushes, pens, ruler, set-square and protractor — for he is dyslectic and has only recently learned to use a computer. But, as The Goons used to say, "it's all in the mind you know."

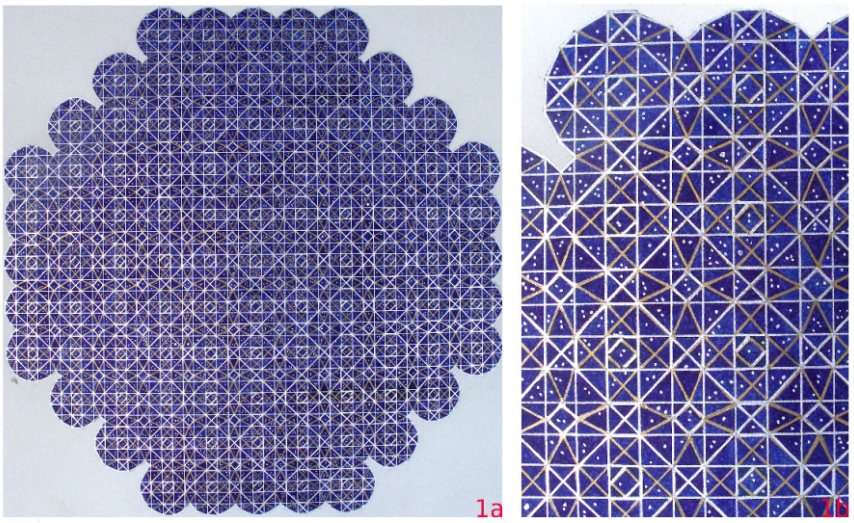


Figure 1 (a) "Untitled", early two-dimensional" ink-on-illustration-board (b) close-up detail of same.

A given theme for the article was "the interface between... the concrete world of objects... and the abstract, mathematical, probability based world of quantum mechanics... How to explain this dichotomy?" For a biologist, the mystery of mysteries is the interface between brain and mind – how does a material network of neurones, bathed in an ever-changing sea of chemicals and hormones (in turn altered by sensory inputs, emotional state, health etc.) produce consciousness - a sense of beauty - the capability to consider and to probe the outer infinity of the universe (to the power of 42?) and the inner infinity of the quantum world? The mystery remains unsolved. We all know that the mind is incredibly flexible, but only recently has it become clear that brain structure itself is remarkably plastic, in that the adult brain can produce new neurones as well as neuronal connections.

Rob Harle, writing for Leigh's web-page (www.leigharnold.com) describes him as working, "at the interface of science and art... inspired by quantum physics, astronomy, mathematics, string theory and other arcane cosmologies... He has the "gift of dyslexia" which... opens up ways of seeing mathematical and geometric images that most of us cannot imagine." Rob's excellent article on Leigh (2) discusses how dyslectics see the world and analyses Leigh's work and some of the math behind it. I recommend both of the foregoing as they contain a broad spectrum of Leigh's works, which would be useful to have in one's mind's eye while reading this article.

Unconsciously, many tend to assume that dyslexia and autism always involve a degree of mental limitation and inflexibility. This is certainly not true of Leigh, despite his diagnosed dyslexia and mild autism. His prodigious output of spectacular work shows significant, systematic, qualitative changes with time - particularly evident since he moved from Victoria [Australia] to the rural "Hippy" community of Nimbin in northern New South Wales. I shall consider the implications of these changes in relation to Leigh's life experience.

I met Leigh in 2006, when he rented our daughter's house near Nimbin. He rhapsodized over the garden and its scattered pots and sculpture as ideal for his beloved Bromeliads. Leigh's dyslexia doesn't extend to the spoken word! Leigh has always been an keen naturalist and, when interviewed for this article, enthusiastically described the beauties and wonders of the natural world of his childhood on the Mornington Peninsular. Yet, despite his love of nature, I see no "biological life" in Leigh's pre-Nimbin work (though others might). To me, they are mind-blowingly beautiful, abstract, geometric figures — although many resemble, in complexity and form, the Radiolarians illustrated by Haeckel.

Before Nimbin, Leigh produced no sculpture. He now does so, in profusion, citing our daughter's garden as an major stimulus. Many of these pieces are geometric, often in Mayan and Aztec style, though there is a recently completed naturalistic male torso (www.leigharnold.com). Leigh's garden is scattered with Mayan-style ruins. Clearly, Leigh's talent is not limited to the strictly mathematical/geometric oeuvre, though he continues to pour out such works, exquisite in complexity and elegance. "Did you have a happy childhood?" — "Yes, until I went to school". I can imagine how he suffered, having a dyslectic grand-daughter myself with school problems in the 21st century. Imagine Leigh's in the 20th.

Leigh has just entered his sixth decade. His parents were market gardeners. His family, on the paternal side, included sign-writers who specialized in "pin-striping" vehicles and Leigh received some tuition there. At school he enjoyed and shone at mechanical drawing — otherwise it was a barren time. He left school as soon as possible, essentially illiterate and without qualifications. Then followed, as he puts it, "a series of sh*t jobs you don't want to know about." He used his earnings to travel

extensively — Asia, Europe, the Middle East. Leigh vividly describes those areas of Petra that never seem to feature in the Rose-Red-City TV programs — the Roman/ Greek/ Persian ruins of a major ancient trading city, centre of a network, of a pattern of trading routes. I repeat — Leigh's dyslexia does not apply to the spoken word. Gradually he taught himself to read, "the TV ads helped", he says, and by the time he reached the age of forty he was comfortable with reading and read for pleasure. How much did the acquisition of this skill help stimulate his artistry?

Leigh did not produce art until he was forty, when his partner died. He subsequently produced much ink-on-board work well before he started reading math. Indeed, Leigh says his math reading arose out of drawing activities. Leigh describes

works. The placing of the fine dark lines reflects his technique of "varying rules of joining points" evident in some recent Nimbin art (Figure 2).

Leigh has produced a large number of works of the ink-on-board type illustrated in Figure 1 — many can be seen on his web page and in Rob Harle's article (2). Each is unique, the complexity and three-dimensionality increase with time — a staggering body of work.

As Leigh started to read formal mathematics he developed what I call his "Cosmic" works — well illustrated in the sources described above. Many are large, (2 x 1m) — the earliest composed on board with acrylic paints and washes and reflective metallic pigment, recent ones on stretched canvas. Typically

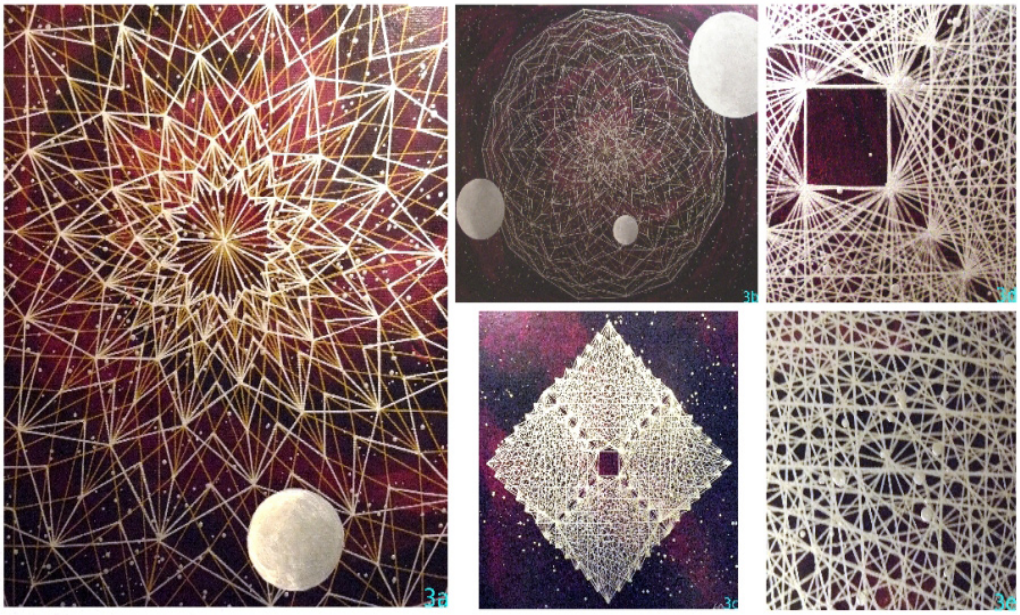


Figure 2 (a) "Untitled", 2008, "Cosmic" work-in-progress; acrylic and metal pigments on stretched canvas (b) & (c) close-up details of same.

Figure 3 Two smaller Nimbin "Cosmic" works. (3a cm (3b) close up detail of centre of same. (3c) "Four 40 cm (3d) close up detail of centre of same (3e) clos

his earliest works as essentially two-dimensional, from which the three-dimensional developed — all in ink-on-board format. Leigh cites circuit-boards as one source of inspiration, evident in early and late works, and linking to his Aztec/ Mayan styles.

Among his earliest work is a fine-textured, blue, multi-lobed shape (Figure 1), which definitely preceded his reading of formal mathematics. But as Leigh emphasizes, he always saw detail in the natural world, and was always highly conscious of the patterns in things. At naked eye level, a horizontal rectangular grid is evident and, less obviously, a diagonal rectangular grid. Even less obvious is a pattern of short darker lines, each joining positions on the rectangular grids to form a complex of intersecting zigzagging lines, which in turn form larger quasi-spherical shapes defining the outer lobes. This complexity can barely be appreciated by naked eye and only became apparent to me via the digital camera's macro-capability — as is true of the tiny dots within the spaces of the grid. These dots foreshadow the minute stars and planets populating Leigh's "Cosmic"

there is background cosmic dust and gas, like that seen by the Hubble Space Telescope. There is always a pattern superimposed - often a complex hexagonal network (Leigh has a deep interest in the hexagon as the basis of... everything?), complex rectangular grids, printed-circuit-Aztec patterns, or three dimensional shapes — his variations are fantastic. Often there are planets in the foreground, but always stars somewhere in the background — peeping through the crevices of the foreground shapes — an endless vista fading to infinity like the galaxies of the Hubble Deep Field.

The "Cosmic" works are hand painted. Lay-out grids are drawn with set-square, protractor and ruler. In the finished work the grid may remain invisible as dots. Some times it is utilized in the finished work — as in Figure 2, an untitled work in progress, "based on the equilateral triangle." It is typical of many of Leigh's Nimbin "Cosmic" works. The dust, gas-clouds, planets and stars remain, but the foreground patterns are more intensive, decorative, abstract - less cosmic, more intimate. Possibly

because Leigh is more relaxed he enjoys experimenting (playing?) with "rules of joining," so that each of the larger triangles/hexagons contains a unique pattern. Leigh started this work with dark-grey ground, coated by blue acrylic. On top of this layer he placed reflective metallic pigments, and this is followed by a wash of diluted blue acrylic to give an extraordinary depth to the gas clouds behind the patterns. All of the background work is done in daylight. The final line patterns are completed at night. Here again we see something that was evident in the work illustrated in Figure 1, the use of color in the lines to produce pattern — in this case the lanes between the larger hexagons and triangles.

Figure 3 shows two more of Leigh's recent "Cosmic" works. The first, Rose is an exquisite example of Leigh's developing style — the planets remain, but there are subtle modulations in shades of red and gold in the background pigments and washes, and of colors in the pattern lines. The close-up view emphasizes these qualities and his meticulous technique, with smaller and smaller stars receding into the far distance. So too the close up views of Four Squares. Here there is no variation in line color but incredible line density giving a remarkable three-dimensionality which is added to by the minute stars. One not only marvels at the mind that conceives these works, but wonders at the brain operating and controlling all the muscles and joints used in executing the work.

There is much pattern in Leigh's art — and a pattern of evolution of the artist. An early life without measurable artistic output, though with valuable technical experience. Travel, reading and perhaps trauma stimulate the impulse to draw. Initial complex two-dimensional work develops into more complex three dimensional images, which stimulate reading of mathematics. This in turn stimulates development of the "Cosmic Images" — ever more complex forms imposed on visions of space, time and infinity. And then he moves to Nimbin! This is another world — a relaxed, organic, caring, encompassing community, bringing together a new set of sensory inputs. He sees sculpture and responds rapidly — with an elegant arrangement of pruned Hibiscus stems in his first local exhibition. His sculpture output increases. "Cosmic Works" become more intense, intimate, abstract, as he relaxes, playing with "rules of joining points."

Most significantly he has started working with fibers, shells, feathers. Figure 4 shows a gradation from Night-mare Catcher, more sculpture than fiber, via Elizabeth, more fiber than sculpture to the wool and feather Nebula. Still the "Cosmic" theme we note — but wool and feather! Where will it end?

) "Rose"; acrylic and metallic pigment on stretched canvas, 76 x 61
Squares"; acrylic and metallic pigment on stretched canvas, 40 x
e up detail of the "circle" at the centre of one of the squares.

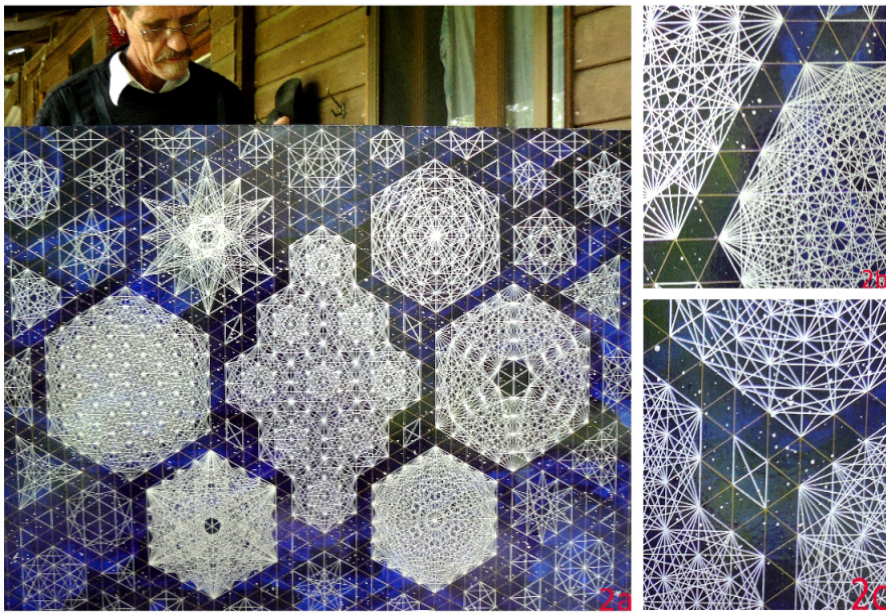


Figure 4 (a) "Nightmare Catcher", mixed media, 2007 (b) "Elizabeth", mixed media, 2007 (c) "Nebula", wool and feathers wall hanging.

Leigh states that he has never felt so at home, so comfortable, so much a part of the community as in Nimbin. I know exactly how he feels! His drive and creativity continue unabated, even increased. What is it in someone's psyche that produces such an intense, unceasing urge to create? His work is ever popular and regularly purchased by us awe-struck, so-called normals.

Acknowledgments
As always, my thanks to my partner and literary adviser Kay for tightening the text.

References
(1) Broadbridge, P. (2007), Letter to Leigh Arnold from Professor Philip Broadbridge, Director, Australian Mathematical Sciences Institute (AMSI), University of Melbourne.

(2) Harle, R.F. (2007) The Gift of Dyslexia: Paintings by Leigh Arnold Sept/Oct HYPERSEEING http://www.isama.org/hyperseeing/07/07-09.pdf

HEALING THE DICHOTOMY OF REALITY:
The Quantum Paradigm

George Weissmann, PhD.
georgeweis@aol.com

Introduction

To appropriately address the theme questions highlighted in Rob's editorial, we embark on a brief tour through quantum phenomena, some basic ideas of how Quantum Theory accounts for them, as well as the radically new thinking that is required to make sense of them which I call the Quantum Paradigm.

Quantum Theory and the Quantum Paradigm

Quantum Theory (QT) was developed in response to the discovery that classical physics completely breaks down for atomic and subatomic phenomena. Unlike classical physics which applies only to a limited range of phenomena, QT turned out to have an apparently general range of applicability, from the very small to the very large. It is the most successful theory in natural science, both in terms of the comprehensive scope of phenomena it applies to, and the precision of its predictions. But it is also the most mysterious, for QT, unlike classical physics, resists an interpretation in terms of an objective reality existing independently of the observer and the act of observation, and endowed with definite intrinsic properties. For example, it makes no sense in QT to ask what a particle is and how it behaves in and of itself, that is, independently of observation, or what actually occurs in a quantum process. Instead, QT describes *our knowledge* (observations or measurements) of the particles only. The usual applicability of the subject-object dichotomy so basic to classical physics, in which we can ignore the subject side and only describe the object side, breaks down. This and a host of other breakdowns of fundamental classical concepts requires a whole new "fundamental paradigm" (defined as a "structure of experiential reality") to ground QT and allow us to make sense of it. This is what I call the Quantum Paradigm.

We now proceed with a few thought experiments which illustrate some essential aspects of quantum phenomena and of the way we have learned to conceptualize them. Each of these experiments has actually been performed in some related form, and the outcomes we describe are the actual ones we would find. These could be visually represented by short film clips, with great benefits for comprehensibility. For quantum phenomena especially, one film clip is worth a thousand static pictures, just as one picture is said to be worth a thousand words. This is because quantum phenomena cannot be described in terms of statically existing objects, but only in terms of *dynamic processes* which involve the dimension of time in an essential way.

First, wearing extremely light-sensitive goggles, we observe a low-intensity electron beam (one electron at a time); by means of light, we see a series of discrete flashes forming an apparent track which we interpret as an electron trajectory. We actually see only the discrete flashes but we mentally fill in the rest of the trajectory (here is the classical paradigm in operation!) to form a continuous trajectory. The way we interpret this — light also consists of particles (photons), so what we observe is the discrete scattering of the photons off the electron, like bullets scattering off a cannon ball, that is why our observation of the electron occurs in discrete flashes though the actual trajectory is supposedly continuous. The more we turn up the light intensity, the closer spaced the track (more collisions).

Next, in a similar vein, we look at a rock moving in a light beam. At first, for the naked eye, the rock appears as an object in the usual way. But as we turn down the light intensity and increase goggle sensitivity and time discrimination (view high speed film in slow motion), we see the rock manifest as a rapid series of flashes which visually fills out its contour in every split second, and which in turn gradually moves along with the rock contour motion through space. This resembles the seemingly continuous image of a rock on a TV screen, which is also composed of a rapid series of flashes on the screen which we conflate into a continuous image. The brighter areas of the rock image are those with more flashes per time. The higher the light intensity, the denser the flashes fill out the contour, and the brighter it becomes. We now see how the illusion of a continuous image is created from *discrete manifestation*.

It turns out that universally all experience, sensory or not, proceeds in *discrete moments of experience*, each of which can be considered a measurement or *distinction* corresponding to a unit of *information*. Interestingly, a similar discovery was made by advanced Buddhist meditators observing their own inner experience two thousand years ago; they called these discrete moments or distinction events "dharmas."

Next we try to control our electron experiment so as to get an event to occur at a specific desired position and time; or equivalently, we try to predict where the next event will occur. But we fail. All we can do by physical manipulation is to create tendency patterns for the next event to occur. As a result, QT operates by assigning to every set of past observations a probability function that represents the tendency for the next measurement to yield any particular result (for example, for the electron to be measured in a particular location). This abstract probability function resembles a wave when visually represented. It is called the wave function of the particle. Causality in QT is not deterministic, but tendential (probabilistic).

Up to this point we may still believe that the electron actually is a small object which continuously, but unobserved, moves from one observed point to the next. But an experiment called an interference experiment (the most famous one being the double-slit experiment) shows us that this is not the case. If we create an experimental arrangement where the electron can arrive from one observation point to the next by one of two distinct paths (for example two slits in a wall, where the particle has to pass through one of the slits to get from an observation point on the left to the next observation point on the right side), then we get a probability pattern (interference pattern) which is incompatible with the notion that the electron went though either one of the holes. Adding up the two patterns due to either one of the holes being open doesn't yield the pattern with both being open. It is as if the probability function of the particle had passed through both holes.

More broadly we learn that the electron cannot at all in general, even theoretically, be assigned specific properties in between observations. Properties like position emerge only from observations/measurements, and as a result of these. In particular there is no continuous particle trajectory between two observation points. From all this we can conclude that the concept of a particle as a classical object fails in the quantum domain.

So what is a particle if not an object? As we saw, QT represents a particle by a wave function that describes the tendential causal effect of a preceding observation event on the subsequent one. A particle represents information about tendency. This reduces to two suggestive slogans: "matter is tendency," and "particles are units of information." But couldn't we simply say the particle IS the wave-function? No, because the wave function clearly behaves like a probability function, not like an object. It spreads out through the abstract mathematical space it lives in (which is not ordinary space), and then collapses when the next observation is made, into a new wave function, which in turn represents the new set of tendencies created by this last observation.

So what we have is observations, creating tendencies out of which new observations are born, and so on. There are no objects in this picture, just observations and tendencies. A particle, and more generally matter, has the nature of tendency. From a quantum perspective, this is true whether we are observing an electron or a rock, it is just much easier to recognize for a micro-system.

To answer another one of the theme questions, what is the status of an object like a rock in the QP? It is an unconscious and conditioned tendency inherent in the Classical Paradigm for reification of a perceived stable process-pattern, as the TV analogy illustrates — there, our eye and mind (visual paradigm) creates the appearance of an object where there is just a rapid series of light flashes. In short, an object is an illusion from the perspective of the QP though a useful one for many practical purposes.

QT splits the world into the observer and the observed, which it treats and describes differently; observed systems (of any size) are treated quantum theoretically (e.g. as wave functions). The observer on the other hand (including his/her measuring instruments, body and brain, which together form the experimental set-up), are described in terms of the classical language of space and time and objects. But there is a catch inherent in this; the observer with his/her body and instruments is made out of the same quantum particles as the observed, which as we have seen turn out to be not objects at all but tendencies that manifest discretely as observation events. The way out of this conundrum is the following: It is a fact that we can move the boundary between observer and observed "inwards" (towards the observer) or "outwards," and QT has a mathematical structure such that its predictions are independent of where we draw the boundary. So if we want to formulate QT consistently, that is without reference to the classical objects which QT itself has found not to exist, then we are prompted to move the boundary inwards all the way to the brain-mind interface so that the whole physical world (including our bodies and brains) belongs to the observed, with our mind as the observer. Now the observation events, so basic to QT, are "mental" events (distinctions). Thus we arrive at a fully self-consistent way of looking at reality, the quantum paradigm, formulated in terms of quantum events that have the nature of distinctions. Complex situations such as this moment's experience are structured sets of distinctions, which give rise to tendencies for the next moment's experience, and so on. The above-mentioned ancient Buddhist meditators called these tendencies "karma," there turns to be a fascinating structural similarity between the Buddhist process model and the QP. Experience is neither subjective nor objective, but comprises both poles.

If we have two (or more) different observers, it was recently clarified that each observer has his/her own account of event history (the "past") and the corresponding tendencies generated by this past. So the facts that constitute "history" or "facts" for two observers do not in general coincide, they are not "objective." However, QT does have the mathematical property of intersubjectivity, which replaces that of objectivity. Whenever two observers communicate about what they have observed, this interaction is itself a quantum event, and establishes consistency between the event histories and tendencies of the two observers. Thus consensus reality is maintained even though objectivity, which is usually regarded as the source of intersubjectivity, is lost.

Postscript

This is only a rough and very partial sketch of the quantum paradigm and the quantum reality it reveals. The quantum paradigm is a radically new vision of reality that not only provides the natural framework for understanding quantum theory and its implications, but also for accommodating consciousness, free will, intention and its effects on the world, entanglement and interconnectedness (non-locality), meaningful coincidences (synchronicity), and so-called psi or paranormal phenomena (a misnomer, as these phenomena have their natural place in the QP). Furthermore, the QP, unlike the classical paradigm, allows for the spiritual dimension of being and provides a framework for a very enriching dialogue between science and spirituality, which can now be seen as two completely different disciplines that nevertheless focus on the same reality and have essential insights to communicate to one another. And finally, when we embody the QP, that is, when it structures our experiential reality instead of acting as a mere theoretical construct, it has the potential to transform us in beneficial ways. This requires disciplined practice, like any spiritual discipline, and is a vast topic in its own right.

I am currently working on a book on the *Quantum Paradigm* to introduce it to the general public. The interested reader will be able to explore the subject in more depth and detail there. Information on the date of publication will begin to be available by the end of 2008 at www.quantumparadigm.org (this Website is currently still under construction). Anyone with the skills for creating such digital film clip programs with variable parameter controls so people can play with simulations of quantum phenomena (for inclusion in an online or DVD version of the book) is kindly invited to contact me.

THERE ARE NO OBJECTS, ONLY EVENTS

Rob Harle
harle@dodo.com.au
www.robharle.com

This article is an overview of my own approach to undertaking research into The Dichotomy of Reality, hopefully it will also inspire other researchers and artists to look past many of the dominant paradigms of Western science, which appears at an impasse in developing a fundamental ontology of existence.

I am specifically concerned with human consciousness and how this characteristic relates to the rest of the universe. Is it an epiphenomenon of the brain-body system or is the brain-body system an epiphenomenon of a universal field of consciousness? Our predominate Western materialistic, scientific view is that it is the former — Buddhist and Vedic Eastern philosophies believe it is the latter. Clearly both cannot be absolutely correct. The ramifications of deciding which of these is the more likely to be correct are enormous, as it entails a completely different metaphysical basis and ontology of the nature of the world and universe we inhabit.

There is now ample empirical and philosophical support for the notion that consciousness is not synonymous with, nor solely located within the brain.[1] Conversely there is no suggested, logical mechanism by which universal consciousness, the ultimate ontological ground of reality, can bring forth entities such as humans with a self (illusory or otherwise) and function temporally with personal memory. It is my contention that neither of these explanations are correct and that a third position, which incorporates aspects of both these antagonistic views, is the more reasonable, logical and scientifically appropriate way to understand our interaction with nature.

To allow a synthesis of these disparate views of the nature of consciousness, I believe our existence as part of and absolute immersion within an all-integrating field of matter is essential. This all-integrating field of matter — omnipresent and all pervasive - is the fundamental basis of reality. I use matter in a special way, not as the "dead" matter of scientific materialism. Different proposals for such fields have been offered since antiquity - Plato's - Form of the Good. The Occultist's — Akashic Record. Sheldrake's — Morphogenetic Field. Jung's — Collective Unconscious. Gibson's (fictional) — Matrix. Science's — Zero-Point Field. The Vedic — Field of Consciousness. Chardin's — Noosphere. The Chinese, Taoist's Way — Cosmological Resonance. Many of these field proposals have been seen, in a sense, as separate from our apparent material existence; this has had the effect of adding support to the Platonic and Cartesian bifurcation of existence and perpetuating the so-called mind-body problem, which my research will show is not a bona fide problem at all. Further to this, the real confusion over the mind-body dichotomy is not so much the separate existence of the two, but how it is possible for a subjective consciousness to arise from matter which up until recently was thought of as dead? An attempt to satisfactorily solve this real problem must understand matter and consciousness as processual events which constitute the all-integrating field.

The "ten thousand things" manifest within this field, such as myself and the pen I am writing these words with. However, as process philosophy, quantum physics, and Buddhism insist, neither myself nor my pen are really solid, static, unchanging material objects - they are "occasions of experience," events (adventures) in process. Some "things" process faster than others; this is simply a temporal facet of their existence, but it has the illusory effect of indicating a fixed, stable object.

As this article title suggests, the methodology used in my investigation is based on process philosophy. My engagement with process philosophy is not slavishly restricted to any one of its branches or major exponents, for example in the Western tradition, Whitehead or Bergson. However, it is guided by the most fundamental aspect, common to all process philosophies, which is a metaphysical general theory of reality that recognises processes rather than stable, unchanging entities as the basic ontological nature of reality. I argue that no basic, fundamental building block exists, unless we are content to call the phenomenon of process itself a building block.

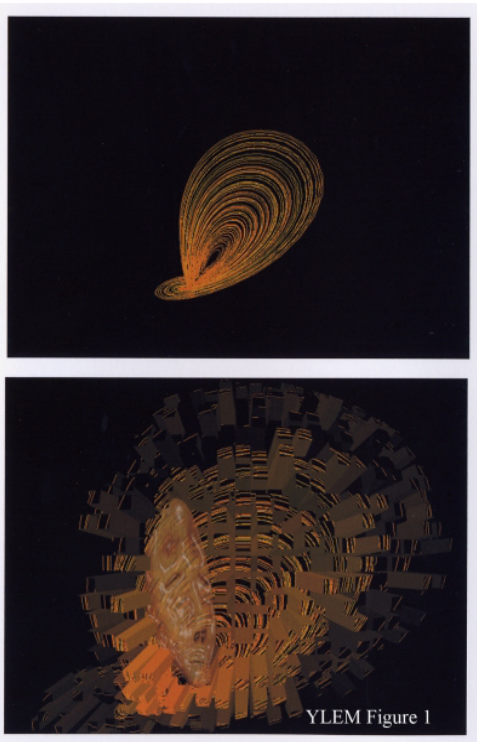
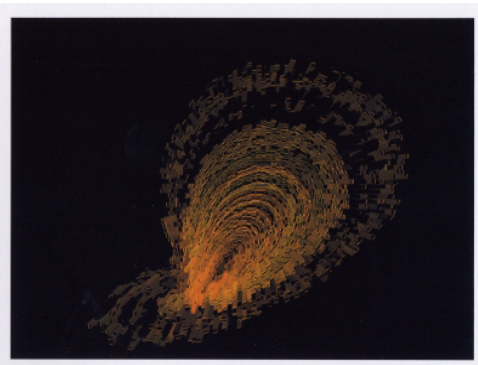


Fig. 1
Observing The Birth of Homo electronicus

In the spirit of Whitehead, I also believe "…the function of philosophical reasoning is "to promote the art of life" by rendering human life and the experienced world meaningful."[2] The realisation that there are no "Objects only Events," in a small, though significant way, helps dilute the powerful assertion by existential philosophers, such as Camus and Sartre, that life is absurd. The process view does not provide a teleological basis to human existence, as does Teilhard de Chardin's schema, nor an eschatology scenario given by traditional monotheistic religions. However, knowing that we are inextricably part of the universe and that the universe is equally part of us in a fundamental, ever changing, developing process, is at least meaningful in a concrete, logical way. As Whitehead insisted, "If it entails a departure from the concrete, that departure is justified only in virtue of a subsequent return". [3] So, though process philosophy departs into speculation and abstraction, at times of the most esoteric kind, it must and does return to the practical experienced world and in this way is a formidable applied philosophy. If the investigation were to yield a finished, closed system which claimed an absolute explanation of reality, then it would be a failure, because the very nature of process is never-ending change, to offer a final explanation about a system which has no finality would be a self-contradiction. "The proper test is not that of finality, but of progress".[4]

The Chinese worked out a process metaphysic, generally entitled Taoism, just before Heraclitus was challenging the atomistic beliefs of philosophers such as Democritus and Parmenides in about 500 B.C. Heraclitus declared we should avoid, "…the fallacy of substantializing nature into perduring things (substances) because it is not stable things but fundamental forces and the varied and fluctuating activities which they produce that make up this world of ours". [5] This is so close to the two fundamental aspects of the Chinese system "ch'i" and "li", and later, the representation of inexorable change in the universal symbol of Yin-Yang, to be seemingly uncanny. I contend that this coincidence or synchronicity is not uncanny at all when we consider the possibility of a universal field that enables preconscious communication, nonlocally. An attempt to provide compelling support for such an all-integrating field is the raison de être of this research. We firstly need to discuss the crucial elements of process philosophy and Taoism.



One of the key concepts explored in this area is "acausal or nonlocal effects." This acausality is a fundamental part of process philosophy, Taoism and the mysterious phenomenon, perhaps artefact, of Quantum physics known as nonlocality. David Bohm first used this term to describe the "…synchronistic, causality violating quantum connection".[6]

The essential new quality implied by the quantum theory is nonlocality; i.e. that a system cannot be analysed into parts whose basic properties do not depend on the… whole system… This leads to the radically new notion of unbroken wholeness of the entire universe. [7]

The idea of "unbroken wholeness of the entire universe" was hardly new in the early 1950s — after all, the Taoist, Vedic and process philosophy of Whitehead (1927) — all embraced this concept. What was new was a scientific, mathematically sound basis for such a concept.

Carl Jung coined the term "synchronicity" from his pioneering work in psychoanalysis and his contact with Chinese philosophy, especially Taoism and the I Ching. "Time and time again I encountered amazing coincidences which seemed to suggest the idea of an acausal parallelism (a synchronicity, as I later called it)". [8] Chinese Taoist philosophy is partly based on "correlative thinking."

It assumes that these related orders [nature, the human and the divine] as a whole are homologous, that they correspond with one another in some basic respect, even in some cases that their identities are contained one within the other. Underlying "correlative thinking" is the notion of cosmological resonance (kan-ying). Correlations, it is held, can interact at a distance by virtue of a mutual sympathy, an idea based on music theory of harmonics". [9]

There are so many correlations between Western process philosophy and Chinese thinking that the Chinese system has in a sense demanded "synchronistically" that it be included in my investigation. Originally I had no intention of including Oriental philosophy but as process philosophy implies, forcing an investigation into strictly preconceived guidelines would be antithetical.

Many aspects of Quantum mechanics are closely related to both process philosophy and Taoism, consequently, as was my intention from the start, these need to be included in the investigation. One of the most striking parallels between Taoism and Quantum physics is the concept of harmonic resonance. Schroedinger thought of the atom as analogous to the vibrating string of a violin. This analogy together with de Broglie's "wave patterns" allowed Schroedinger to develop an equation which "…provided a continual mathematic description" of atomic harmonics. [10] "This was just what was needed to explain the observed frequency of the light waves or *photons* emitted when the electron in the atom undergoes a change from one orbit to the other [my emphasis] (ibid.) This scientific validation of "photonic harmonies" is of considerable importance to my research. The fairly recent mathematical proof by Reuda indicating "…the existence of a background sea of light known as the electromagnetic zero-point field of the quantum vacuum"[11] fits in perfectly with the atomic and subatomic harmonic proofs mentioned above. "The solid, stable world of matter appears to be sustained at every instant by an underlying sea of quantum light". [12]

My research concept does not venture into the discipline of process theology, nor do I discuss the concept of God in any other traditions, as the existence of such an entity would neither add nor detract from my particular purpose. This purpose I should make clear from the start is not to develop a complete, self-contained metaphysical system, but to investigate a major attribute of such a system which has already been thoroughly developed by philosophers such as Whitehead and Chang Tsai, and to explore some of the relevant aspects of Quantum physics.

Whitehead's process philosophy can stand alone as a coherent, complete system without the inclusion of the concept of God. Though he includes God as an "actual entity", similar to everything else in the universe, it is nevertheless not the same, in fact, God can be seen in Whitehead's system as fulfilling a traditional, largely Judeao-Christian role, "God exhibits his [sic] traditional saving power and his [sic] judging power". [13] Given Whitehead's fanatical attention to the correct usage of language — understanding his philosophy is based on understanding his neologisms — his usage of "He, Him and His" when discussing

God is highly suspicious to me of a perhaps subliminal attempt to incorporate his preconceived ideas of a traditional Christian God into his metaphysical system. Some critics would I believe argue that his system, like that of Giordano Bruno's, would be better off without the inclusion of God. Similarly it was not necessary to the coherency of the system for Chinese philosophers to include an ultimate primordial agent who orchestrates the never ending process of change into their system either.

Both Teilhard de Chardin's "Noosphere" and Rupert Sheldrake's "Morphogenetic Fields" are postulates of a kind of background field which intimately links biological entities and the universe together. The noosphere as Teilhard envisaged it is not synonymous with my concept of an all-integrated field. He believed the noosphere was a kind of evolving organ specifically related to our own planet; its development or emergence he saw as analogous to the emergence of the cerebral cortex in homo sapiens. This is not to say that he believed only one noosphere existed in the universe, there would be, "… as many noospheres as there will be thinking planets in the firmament". [14] The existence of an all-integrating field however, does not in any way preclude the existence of the noosphere.

Similarly, Jung's explanation of the "collective unconscious" is not synonymous with an all-integrating field. He believed the "primordial deep level of unconsciousness" — the collective unconscious — was genetically hard-wired, was independent of culture and contained archetypes which had evolved along with other human traits. With a little imagination is not hard to see how an all-integrating field could be extended to explain Jung's collective unconscious, just as it may also explain the realm a traditional Shaman visits in healing journeys.

Sheldrake's Morphic or Morphogenetic Fields are more closely aligned to an all-integrating field, because he considers these morphogenetic fields to be of a universal nature which encodes the basic pattern of an object. However, whereas Plato's "Forms" were eternal and unchangeable, master templates so to speak, Sheldrake's forms evolve in a somewhat similar way to Whitehead's "actual entities" which are always part of an ongoing process.

These rather speculative concepts, all of which have raised the criticism of mainstream science need to be included in the research because they add support to my synthesis, though they are not absolutely necessary to provide backing or clarification of this. In one sense they help to define what an all-integrating field is not.

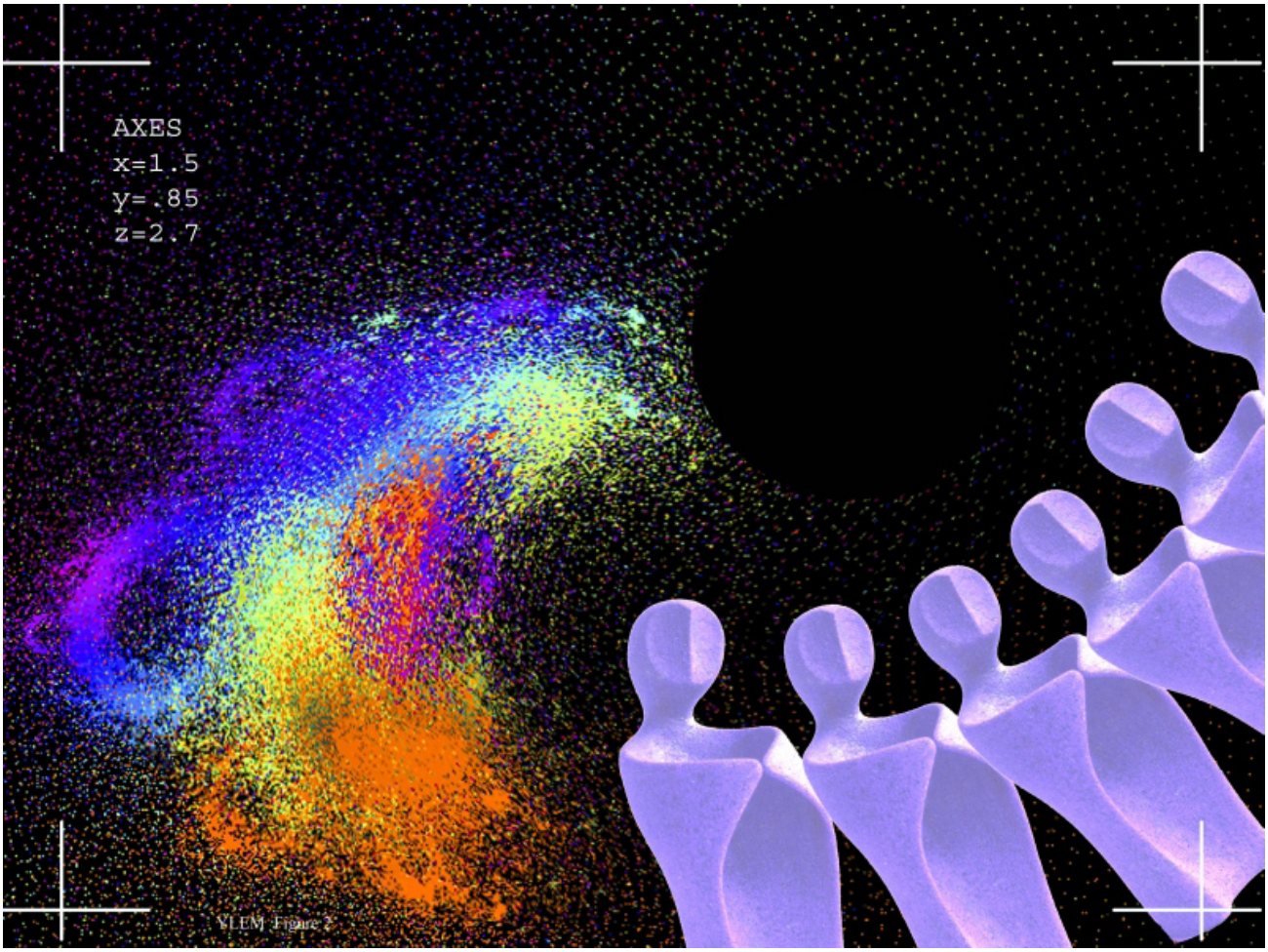


Fig.2 Nanoscan of a Thought Emerging from the Visual Cortex

The nature of consciousness is the most problematic factor in this research, however, we do need to come to grips with this notoriously slippery phenomenon. An attempt to more clearly

understand human consciousness is the original driving force of my research and most of my digital artwork. This research, formally commenced with my Honours thesis [15], then was followed by various publications [16] concerning the possibility of disembodied consciousness, that is, consciousness without a bodily support system. Specifically, the notion of surviving bodily demise with memory continuity of self.

The really hard problem of consciousness is not how does the qualia of mentation occur, nor, how does subjectivity arise from apparently dead non-subjective, non-sentient matter, nor trying to pinpoint the exact location of consciousness (in the thalamus, in the big toe or throughout the body) for example. The hard problem which should concern us the most is — Can conscious self-awareness exist without some kind of body? If this can be decided then many of the other questions will be automatically answered and those that cannot will be at least more clearly delineated.

After investigating the abovementioned areas we need to combine the relevant aspects of Process Philosophy, Chinese Taoism, Quantum mechanics and an understanding of consciousness to form a synthesis. This will explain the nature of human consciousness and its relationship with an all-integrating field, which although in a very special sense is itself a living, conscious phenomenon, does not have determining, teleological, anthropic qualities.

I think it is important to include a brief outline of my position concerning postmodernist theories of meaning, knowing, and construction/deconstruction. As Krauss mentions, sound metaphysics should avoid provincialism and have a focus of practical application. "For a scheme to be genuinely metaphysical, it must be applicable beyond the limited confines of its starting point, having achieved some relatively universal perspective". [17] I contend that deconstructive postmodernism does not offer a universal perspective. Its acknowledgement of, "… the inadequacy of reason, philosophy, and science to give us a coherent and final answer to cosmological questions such as the nature of reality, of matter, and of mind" [18] while partly correct, is misleading because it is both a dogmatic assertion and is coming out of our Western intellectual tradition; consequently, it is simply irrelevant to various native cultures, such as the traditional Australian Aborigines. Exactly, a deconstructionist postmodernist would argue, their system is reality to them, but not to us, because it is culturally determined. However, if we come from the aboriginal cosmological position, they would argue that their system is universal, and if we were educated enough in their culture, we would know this. This situation results in a kind of paradoxical impasse. There is a way out, however, known as constructive postmodernism, which I discuss below.

In agreement with de Quincey's view, I also contend that postmodernism developed to counter the abject failure of modernism to provide universally absolute answers which it had the arrogance and myopic vision to think it could provide. Deconstructive postmodernism has in a sense left us, especially in the developed Western world, in a worse position than the illusory promises of modernism, that is, to provide absolute answers for everything. It has correctly shown us the futility of looking to science, religion, or philosophy to provide these answers, and even the possibility that such answers are attainable. However, in its wake we are left with a hopelessness and meaninglessness - nihilistic relativism — that allows no way forward. If we adopt a position of constructive postmodernism as Griffin and de Quincey suggest, there is a solution which has a universal perspective, and as such includes all cultures and people on this planet, and, if they exist, on other planets, for that matter. [19] Constructive postmodernists also recognise, "…the impossibility of a secure and certain epistemological foundation, [and] declare that therefore this is all the more reason for reinvigorating our efforts at creatively constructing coherent systems of ontology and cosmology". [20] So this way does provide answers to questions concerning the nature of reality, but the answers offered are not as dogmatic ultimatums but as provisional solutions to a "work in a progress" – the unfolding evolution of a conscious universe. Provisional means "under terms not final or fully worked out or agreed upon;" this, nonetheless, does not make them incorrect, nor mere wild speculations. Perhaps, rather than the black and white situation of either dogmatically asserting that how we know things is far more important than what we know, following Kant, (which I have argued elsewhere is untenable), [21] we should in the method of process philosophy, in a sense, combine these two disciplines in a sort of feedback loop, each adding to the other in a complementary "concrescence."

Trying to clearly express such a "concrescence" in visual art form is a lot harder than it seems at first glance. The main problems I am attempting to overcome are: firstly, what does the "quantum zero-point field," or Adler's "pre-quantum level of physical fields as yet unknown to physics," actually look like? This is a non-trivial problem. As George and Julian discuss in their articles (this issue), in one sense quantum phenomena don't actually look like anything; for example, electrons don't really look like the classic billiard ball model. What we need to achieve is a way of showing visually the dynamic process that is happening at these pre-quantum levels. It may be necessary to develop visual metaphors which accurately describe these states. The second difficulty is that we are not spectators looking out at the all-integrating field, like looking at distant galaxies; for example, we are totally immersed and part of the field, so how does it appear from the inside out, as it were? How can we visualize and then represent the ontological "Fieldscape"? My first tentative 2D images are shown in: Fig. 1 "Observing The Birth of Homo electronicus" this image shows a human-like figure emerging from within a fractal (Lorenz) matrix, which is itself emerging from the great black beginingless < > endless void — of Eastern spiritual traditions — the "Fieldscape"? The second image, Fig.2 "Nanoscan of a Thought Emerging from the Visual Cortex," is expressing visually how a thought generates a 3D image from, again, the void and a fractal matrix. I am beginning to think that 2D images just cannot adequately convey the complexity of the dynamic process of an all-integrating field, and, perhaps as George has suggested, moving images or animation might be more effective. Regardless of the problems in artistic methodology, I believe the effort is worthwhile, because as many great scientific breakthroughs have shown, visually modelling was actually the key to making the discovery.

This is where organisations like YLEM, ISAST and ANAT (Australia) are so valuable; as they encourage and promote residencies and liaisons with scientists, this enables artists to present these concepts as visual, sonic-audio or performance pieces. I see these liaisons as absolutely symbiotic. The artist can help scientists understand principles of art (composition, colour theory, the narrative) and also the artist's way of comprehending existence. If scientists do not apply these skills to their own images, say photographs through an electron microscope, which may well be aesthetically stunning, they probably will not result in enduring works of art. Works of art need an intrinsic story! Hopefully we are getting a little closer to understanding the story of existence through the harmonious interaction of science and art.

References:

1 Harle, R. F. "Disembodied Consciousness and the Transcendence of the Limitations of the Biological Body." Janus Head 9.2 *The Situated Body* (2007). pp. 589-603
2 Kraus, E. M. *The Metaphysics of Experience: A Companion to Whitehead's Process and Reality*. New York: Fordham University Press, 1998. p. 42
3 Kraus op. cit. p. 41
4 Whitehead, A.N. *Process and Reality: An Essay in Cosmology.* Corrected Edition. Edited by D. R. Griffin and D. W. Sherburne. New York: The Free press, 1978. p. 14
5 Philosophy, Stanford Encyclopedia of. "Process Philosophy." (2002), (1) Historical Aspects. http://plato.stanford.edu/
6 Wolf, F. A. *Taking the Quantum Leap*. Cambridge: Harper & Row, 1989. p.177
7 ibid.
8 Coward, H. "Taoism and Jung: Synchronicity and the Self." Philosophy East and West 46, no. 4 (1996). p. 477
9 Coward op. cit. p. 478
10 Wolf op. cit. p. 94
11 Haisch, B. "Brilliant Disguise: Light, Matter and the Zero-Point Field." Science and Spirit Magazine (2001), http://www.science-spirit.org/printerfriendly.php?article_id=126
12 ibid.
13 Sherburne, D. W. (ed.). *A Key to Whitehead's Process and Reality*. Chicago: MacMillan Publishing, 1966. p. 227
14 Teilhard de Chardin, P. *Activation of Energy*. New York: Harcourt Brace Jovanovich, 1971. p.127
15 Harle, R. F. "The Myth of the Freudian Unconscious and Its Relationship with Surrealist Poetry." Deakin University, 2000.
16 Harle, R. F. "Cyborgs, Uploading and Immortality - Some Serious Concerns." *Sophia: International Journal for Philosophy of Religion, Metaphysical Theology and Ethics* 41, no. 2 (2002).
17 Kraus op. cit. p. 44
18 de Quincy, Christian. *Radical Nature: Rediscovering the Soul of Matter*. Montpelier, VT.: Invisible Cities Press 2002. p. 149
19 de Quincey op. cit. pp. 149-155
20 de Quincey op. cit. p. 151
21 Harle, R. F. "Kant and Aquinas: Regarding the Transcendence of Reason." Geelong: Deakin University, 1996 www.robharle.com/

iRobot SwarmBot

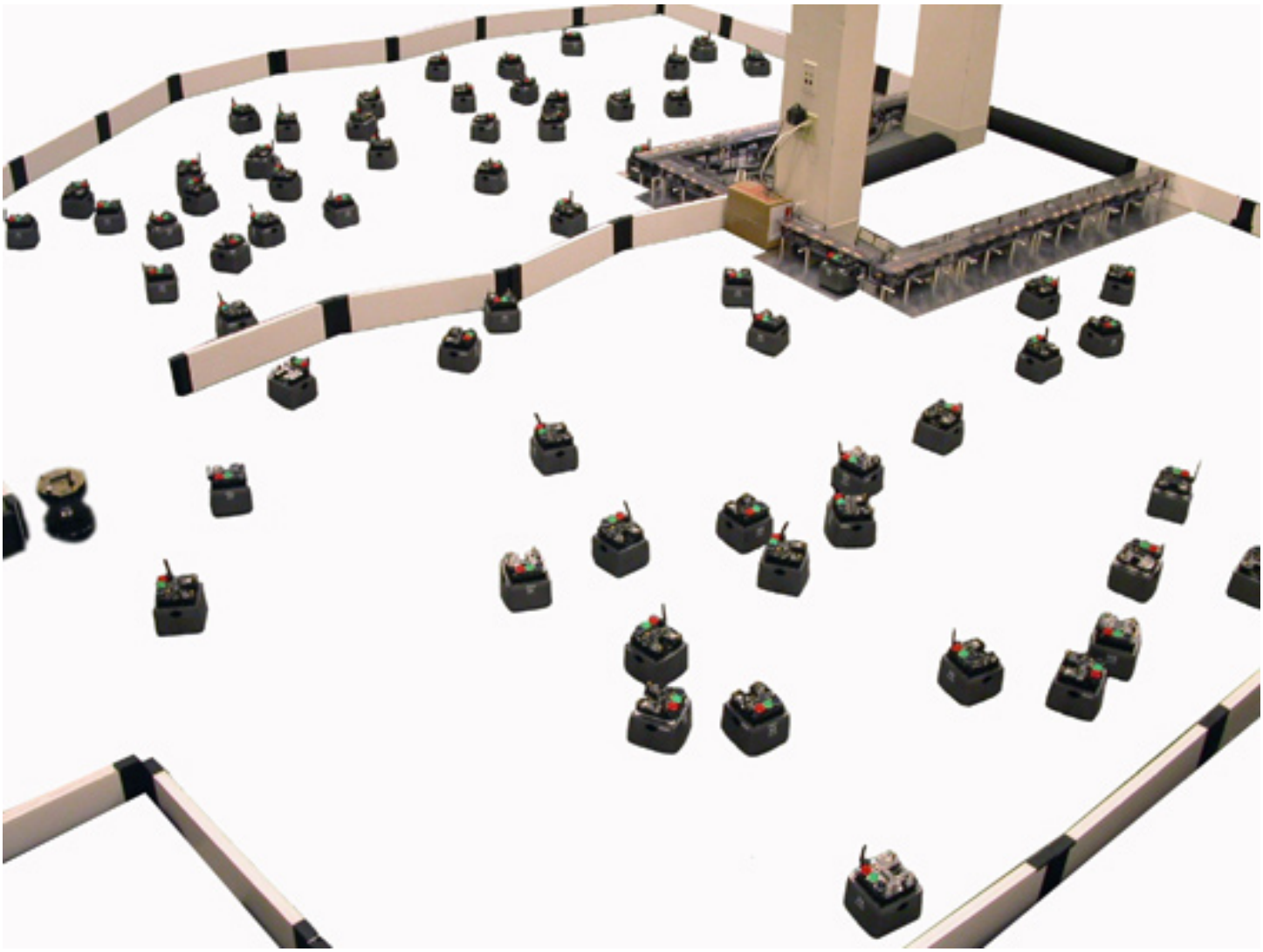
VERNOR VINGE'S CONCEPTION OF "GROUP MIND" AS IT PERTAINS TO CONTEMPORARY ROBOTICS APPLICATIONS

Loren Means

A salient feature of Vernor Vinge's novel *A Fire upon the Deep* is the manifestation of "Group Mind" in an alien group he called the Tines. In a recent email, Dr. Vinge says "Group minds have a long history in sf. In reading *The Starmaker* [Stapeldon] it occurred to me that small count group minds had rarely been done…(Of course small count group minds have been done in sf, and very well—Poul Anderson's tripartite minds in *Rebel Worlds*. Though perhaps they haven't been done as often as large count minds.)" Stapeldon and Anderson's group minds are pure speculation, of course, as are Vinge's.

Dr. Vinge's "Group Mind" concept is manifested in multifarious ways in contemporary applications of distributed communication and group interaction in robotics. Groups of robots are being seen to accomplish tasks with a minimum of onboard intelligence, in an approach called "bottom-up robotics." This is an alternative to the "top-down robotics" approach, which began with the concept that an individual robot had to use enormous amounts of computing power to model its entire environment before it could take even a single step. Instead, groups of simple robots with low intelligence are turned loose on an environment using swarm intelligence, emergent learning, and evolutionary breeding to produce groups of robots that learn their environments and their tasks by interacting with the environment and each other, reconfiguring the structure of the group as conditions warrant. These "Swarmbots" communicate with each other via flashing lights and radio-broadcast sounds, but they also communicate by a method of indirect communication known as stigmergy, modifying their environment through the use of pheromones, modeled on ant and termite behavior. Other roboticists are causing their robots to teach themselves to fly in swarm formations like flies. Ultimately, the intelligence that can be generated by such swarm communication can result in a distributed parallel computer that programs itself.

Science fiction has a number of tropes which are utilized on an ongoing basis, even in so-called "hard science fiction," irrespective of their lack of genuine scientific foundation. Among these tropes are faster-than-light travel, time travel, and humanoid robots with "positronic brains," which usually stand in for civil rights issues. Much actual scientific research is being conducted in the area of humanoid robots, but researchers agree that the implementation of this concept is probably at least a hundred years away. More positive results are being achieved all over the world in the area of cooperation between groups of fairly simple, low-intelligence robots that resemble nothing other than the machines they are. One of the most successful of these ventures is in the area of robot soccer, as manifested in annual RoboCup tournaments. The lack of reference to multi-robot groups in science fiction is an example of the gap between the tropes of science fiction and the real, and very exciting explorations being carried out by contemporary scientists.



Swarm from above — iRobot's SwarmBots

Multi-robot systems are currently being deployed in a wide range of applications, including bomb location, reconnaissance, search and rescue operations, teleoperation in nuclear environments, and hostage monitoring.

Programmers at the Robotics Research Lab of the University of Southern California have created two software programs, Player and Stage, for communications and task allocation for multiple-robot groups. As Gerkey, Vaughan, and Howard put it, "Player is a robot device server that provides network-transparent robot control. Player seeks to constrain controller design as little as possible; it is device independent, non-locking and language- and style-neutral. Stage is a lightweight, highly configurable robot simulator that supports large populations.

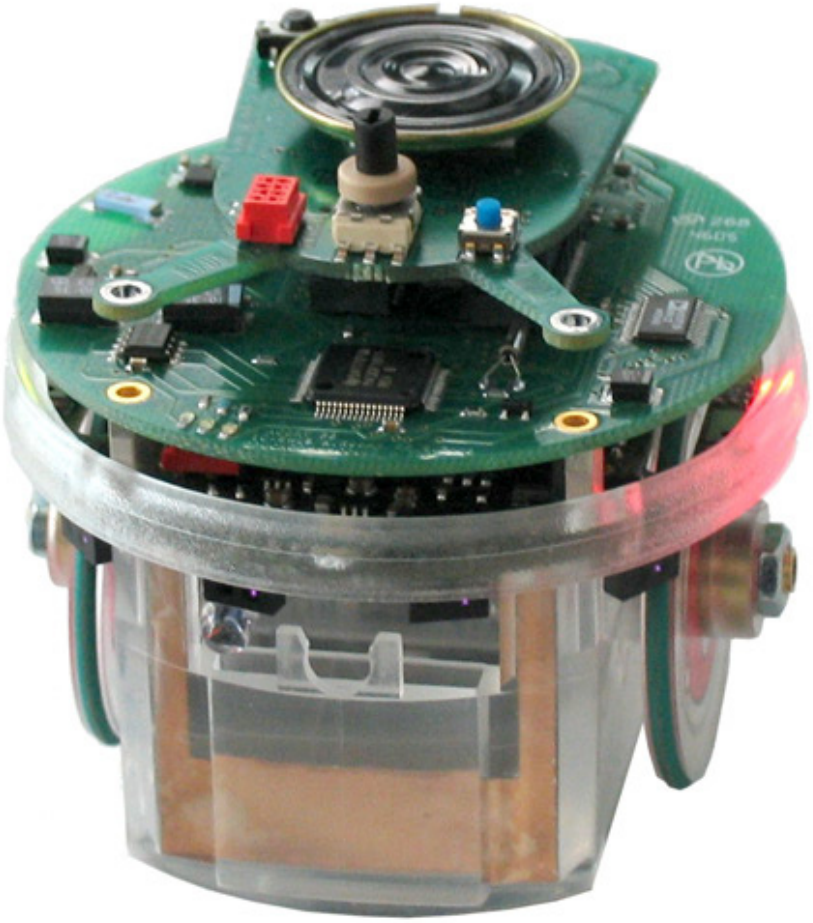
"Stage's modular architecture makes it easy to add entirely new models in order to explore less common ground: 'What could I do if my robots could change color at will, or visually express some internal states to their colleagues, or quickly recognize and categorize each other?'. Exploring the use of devices that are not currently feasible opens up a new field of study; robotics as it could be. Freedom from practical constraints distinguishes science from engineering; having a means to perform experiments distinguishes science from science fiction." [1]

One of the principle funders of robotics research in the US is the Department of Defense. Robot groups are currently deployed for bomb location, reconnaissance, and rescue operations, but the implication of this funding push is that robots will eventually be utilized in combat. As Edelen puts it: "Cooperative hunting has become of great importance to the military, due to a number of factors:
Physical
o Robots can access and maneuver in space too small for humans.
o Robots survive in contaminated environments.
o Robots can remain motionless indefinitely.
Psychological
o Robots are not influenced by fear in carrying out military operations.
o Robots complete tedious tasks without suffering mental fatigue.
Risk
o Robots can perform kamikaze missions.
o Inexpensive robots can be chosen for high-payoff/high-risk situations." [11]

This raises all sorts of ethical questions, and even gives rise to new terminology. In their paper, "Lethality and Autono-

mous Robots: an Ethical Stance," Arkin and Moshkina of the Georgia Institute of Technology College of Computing not only use the term "lethality," but go on to state: "If the military keeps moving forward at its current rapid pace towards the deployment of intelligent autonomous robots, we must ensure that these systems be deployed ethically, in a manner consistent with standing protocols and other ethical constraints that draw from cultural relativism (our own society's or the world's ethical perspectives), deontology (right-based approaches), or within other related ethical frameworks. This class of autonomous robots that maintain an ethical infrastructure to govern their behavior will be referred to as humane-oids." [3].

Another interesting term coined in robotics research is "greedy mapping." As Koenig, Tovey, and Halliburton of Georgia Tech point out, "Mapping is an important task for mobile robots… Greedy Mapping [is] a simple sensor-based planning method that always moves the robot from its current location to the closest location that it has not visited (or observed) yet, until the terrain is mapped. Greedy Mapping assumes that the location of the robot is always known, for example, from GPS data. It is greedy because its plans quickly gain information but do not take the long-term consequences of the movements into account. Yet, the travel distances of the robot are reasonably short." [4].



The ZigBee ready communication turret

Roboticists at Carnegie Mellon University promote multi-robot communication and co-operation through pattern formation. As Bahceci, Soysal, and Sahin put it, "The pattern formation problem is defined as the coordination of a group of robots to get into and maintain a formation with a certain shape, such as a wedge or a chain. Current application areas of pattern formation include search and rescue operations, landmine removal, remote terrain and space exploration, control of arrays of satellites and unmanned aerial vehicles (UAVs). Pattern formation is also observed in various animal species as a result of cooperative behaviors among its members, where the individuals stay at a specific orientation and distance with respect to each other while moving, or fill a specific area as homogeneously as possible. Examples of pattern formation in animals include bird flocking, fish schooling, and ants forming chains.

"One strategy for robot formation is inspired from the way molecules form crystals. Each robot has several local attachment sites that other robots may be attracted to. This concept is similar to molecular covalent bonding…Various robot formation shapes result from usage of different attachment site geometries just as different crystal shapes emerge from various covalent bond geometries. When a team of robots moving in a formation, they avoid the obstacle by splitting around it and rejoining after passing.

"Another approach is to use local information to establish and maintain formations among robots. Each robot has a unique ID and a designated friend robot which it can see through a .friend sensor. There is also minimal communication between robots: heartbeat signals (robots broadcast their IDs), swerve signals (changing direction), and formation messages. Each robot can learn the number of robots in formation and the type of formation using broadcasted messages." [5].

The Robotics Research Lab at the University of Southern California takes a slightly different approach to multi-robot cooperation. As Batalin and Sukhatme put it, "in order to achieve good coverage as a team, robots must 'spread out' over the environment, i.e. if robots are too close to each other, their coverage areas overlap resulting in poor overall coverage. This premise is loosely inspired by the diffusive motion of fluid particles. Thus, robots not only perform obstacle avoidance, but are mutually repelled by each other within the range of their sensors… In addition, the motion of every robot is guided by its perceived coverage area, that is, individually robots try to move in the direction of coverage maximization. This is a local greedy approach." [6].

A fecund area of research into group cooperation and emergent behavior in robots is called Swarm Robotics. The term was coined by Gerardo Beni in 1989, and he defined it as "a prop-

Jasmine robots in rows

iRobot SwarmBots in a row

erty of systems of non-intelligent robots exhibiting collectively intelligent behavior." [7]

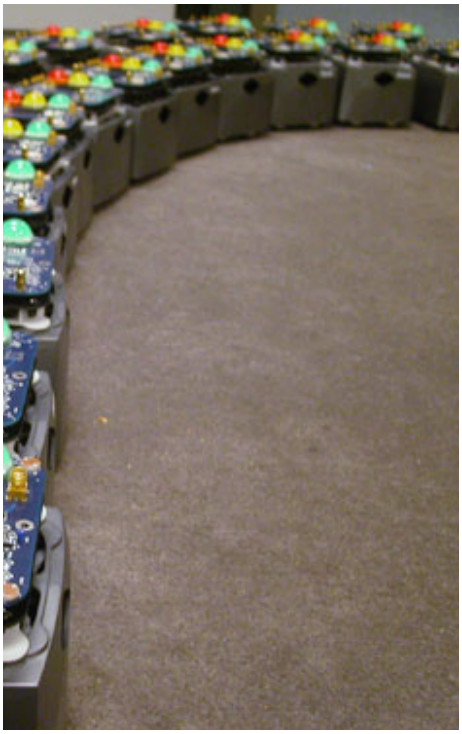
A pioneering paper in this area was published in 1990 by Rodney Brooks, Patti Maes, and Maja Mataric, three of the most prominent of contemporary roboticists. The paper was called "Lunar base construction robots." The paper suggested that instead of deploying expensive individual robots whose breakdowns in space would render them irreparable, large quantities of small, inexpensive and therefore expendable bulldozer robots that could teach themselves to perform complex tasks. This lead to Brooks coining the phrase "fast, cheap, and out of control" to characterize these robots and the concept of "bottom-up" rather than "top-down" robotics. In 1997 Brooks was featured in a satirical documentary by Errol Morris called, "Fast, Cheap, & Out of Control."

Swarm robotics tends to study the behavior of fauna in the natural world and apply the concepts found there to robot behavior. Prominent in these studies is the behavior of ant colonies from all over the world. A salient component of ant behavior is the use of pheromones. As Payton, Estkowski, and Howard of HRL Laboratories in Malibu, CA, put it in "Compound Behaviors in Pheromone Robotics": "Emerging technologies in micro machining and Micro-Electro-Mechanical Systems hold the promise of creating extremely small robots. Although limited in size and power, such robots can work together in large numbers to conceivably accomplish a wide range of significant tasks including surveillance, reconnaissance, hazard detection, path finding and payload conveyance.

"We are inspired by techniques used by ants and termites for communication and coordination. We implement 'virtual pheromones' using simple transceivers mounted on each robot. Like their chemical counterparts, our virtual pheromones facilitate simple communication and emergent coordinated movement with only minimal on-board processing. But virtual pheromones go a step further, transforming a robot swarm into a distributed computation grid embedded in the world. This grid can be used to compute non-local information about the environment such as bottlenecks and shortest paths, in ways that are foreign to insect colonies.

"In our approach, we envision a scenario in which a rescue team enters an unfamiliar building after a disaster, and needs to quickly locate any survivors. We imagine multiple tiny robots released at the entrance to the building. Using simple attraction/repulsion behaviors, these robots quickly disperse into the open spaces. Upon detection of a survivor, a robot emits a virtual pheromone message signaling the discovery. This message is propagated locally between robots only along unobstructed paths, producing a gradient as it is propagated. Ultimately, the message makes its way back to the entrance where rescue team members can now follow the pheromone gradient to the survivor. To do this, the robots themselves serve as a distributed display of guideposts leading the way along the shortest unobstructed path. We are pursuing this vision with 20 small robots specially designed to support our virtual pheromone type communication protocols.

"Traditional approaches to path planning and terrain analysis operate on an internal map of terrain features or they perform the steps of sensing, data transmission to a central point, and map generation before the data can be processed. This is especially disadvantageous when the environment is rapidly changing. Pheromone robots (or pherobots) require no centralized map, nor do they maintain a detailed history.



SwarmBots — several s-bots linked together

"Pherobots implement an efficient and versatile distributed computer. In some applications the results of the computation are sent back to the user via relayed messages. But the real novelty of the system is when the robot swarm acts as a distributed display embedded in the environment. In effect, each robot becomes a pixel, or an annotation on the immediate environment. The robot's position with respect to the user provides context to interpret the meaning of the transmitted information." [8]

As Bayinddir and Sahin put it, "A mechanism similar to the one used by ants is applied to the multi-robot object aggregation problem: crumb handling behavior. In this behavior, the robots drop 2 crumbs if they carry a sample. In addition to this, if the robots do not carry an object and crumbs are detected, the robots pick up one crumb. With this mechanism, a positive and a negative feedback mechanism is being added to the system and the communication between the robots are being handled using the environment itself without a need to have complex mechanisms to handle communication.

"Subsumption architecture [another term coined by Rod Brooks] is one of the distinguished and classical architectures in behavior-based robotics. The architecture allows efficient coordination of behaviors by using a simple inhibition mechanism between the behaviors and incremental building of robot controllers by considering each behavior as a separate module which can inhibit other behaviors. Mataric presented design of some behaviors from simple to complex using subsumption architecture in a clear way. The behaviors designed are collision avoidance, following (inverse of collision avoidance), dispersion (used in order to balance goal-directed behavior against interference), aggregation, homing and flocking.

"Probabilistic finite state automata (PFSA) is a way to represent dynamical systems with finite state spaces. In a probabilistic automata, the transitions between the states of the system are triggered with certain probabilities. The general approach is to model the robot behaviors as states and define the state transitions with some external input and probabilities. Labella, Dorigo, and Deneubourg applied a PFSA based adaptation algorithm to a prey retrieval task. The PFSA based controller of the robots has the Search, Retrieve, Deposit, Rest and Give Up states which are in fact the robot behaviors…They tested the algorithm on Lego Mindstorm robots and showed that task allocation occurred between the robots because of the minor mechanical differences of the robots. At the end of experiments, some of the robots became foragers and the others became loafers.

"Probably the most difficult and classical problem in machine learning [is] the credit assignment problem. Both temporal and spatial credit assignment problems exist in multi-robot problems since the actions of the robots can be rewarded with a delay and the result may depend on the actions of multiple robots. Reinforcement learning studies can be divided into two categories: the studies which use local reinforcement and the ones which use global reinforcement. In the former one, the reinforcement is only given to the robots which are close to the location where the reinforcement is generated. In the latter one, all robots are rewarded as if the last action is a result of the collective actions of all robots. In other words, even if some robots do not contribute to the goal, all of the robots are rewarded in a global reinforcement scheme. Tangamchit, Dolan, and Khosla of Carnegie Mellon's Robotics Institute showed that a local reward scheme does not produce cooperative behavior since the robots do not want to help other robots if they cannot get any reward." [9]

Communication is an essential component of cooperation within robotic groups. As Arai, Pagello, and Parker put it, "Distinctions between implicit and explicit communications are usually made, in which implicit communication occurs as a side effect of other actions, or 'through the world', whereas explicit communication is a specific act designed solely to convey information to other robots on the team." [10]

As Mark Russell Edelen put it, "Explicit communications become increasingly complex as the number of robots increases. For very large groups of robots, these schemes may become impractical. Implicit communication, also known as stigmergy, occurs through the environment. This type of communication scales well for potential future applications requiring hundreds or thousands of robots. It is most often implemented in cooperative foraging, clustering, or sorting tasks. Messages are 'sent' only by altering some aspect of the environment which is then sensed by another individual robot. The environmental alteration can be intentional, as in the case of trail-laying, or unintentional, as in clustering or sorting tasks.

"Beckers, Holland, and Deneubourg designed a robotic foraging system using pure stigmergy. In order to collect a random distribution of pucks in an experimental foraging environment, the robots pick up or release each puck based solely on the local puck density…The multi-robot system forages successfully and achieves cooperative behavior with completely indirect communication." [11]

Symbion collaborating bots build a structure

As Beckers, Holland, and Deneubourg put it in "Stigmergy and Collective Robotics": "Behaviour-based robotics has given new force to the branch of AI concerned with situated agents and embedded systems. As well as effective slogans ('the world is its own best model') and important new ideas ('emergent functionality') the field has generated a deep conviction that systems for the real world must be developed in the real world, because the complexity of interactions available for exploitation in the real world cannot be matched by any practical simulation environment.

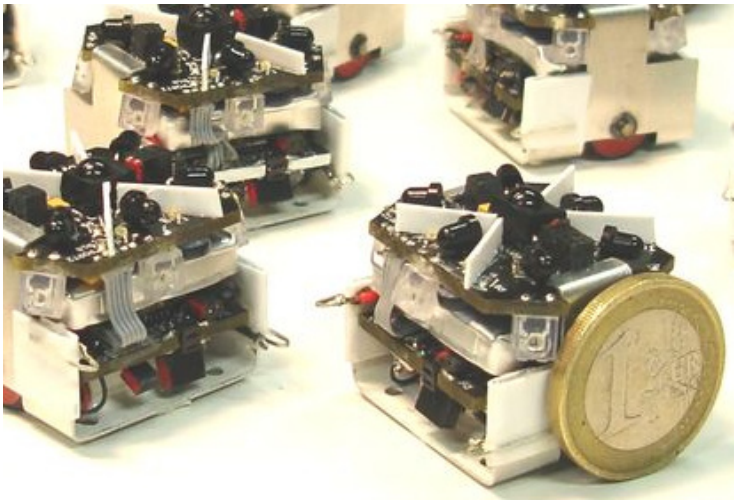
"A stigmergic communication requires no encoding or decoding, no knowledge of place, no memory, and it is not transient; all it requires is that a robot passes near enough to the location where the communication was placed to be affected by it… In fact, the environment can be regarded as a sort of external memory, accessible to all. Pursuing this analogy, the use of volatile pheromones in the environment may represent a type of short-term memory. Perhaps stigmergy is best regarded as the general exploitation of the environment as an external memory resource." [12]

As Fleischer and Troxell of Colorado State University put it, "In foraging, several systems have tried to create a dynamic based on how some insects use a pheromone trail for navigation and as a means of encoding the location of interesting objects such as food. One low fidelity approach has been to use a chain of robots that forms a beacon path for guiding other robots in the same way that the pheromone trail guides the insect. The opposite end of the spectrum is demonstrated by Kuwana, Shimoyama, and Miura, who attached the living antenna of a male silkworm moth to a mobile robot, and demonstrated that it could follow a live female's pheromone trail. Somewhere in the middle lies the work of Russell, Thiel, and Mackay-Sim, who demonstrate a robot which follows a camphor trail by means of a gravimetric sensor crystal that can measure the deposition of the volatile camphor molecules on its specially treated surface. These examples demonstrate the range of possibilities when translating a biological system into the mechanical world." [13]

Mamei and Zambonetti of the University of Modena in Italy are critical of most pheromone-based approaches, stating that they "realize pheromones by means of adhoc physical markers (special ink, metal dust, water on brown-kraft-paper, etc.) However, in our opinion none of them propose valid solutions to actually spread pheromones in real-world everyday environments (who really wants pheromone graffiti covering his/her home?!). In this paper we propose an ubiquitous computing version of pheromone deployment based on [Radio Frequency Identification] RFID tags. The key idea of our approach is to exploit the fact that RFID tags can be written on-the-fly by suitable wireless devices, called RFID readers (which are also writers despite the name). On this basis, RFID readers, carried by a human or embedded in a robotic agent, could deploy pheromone trails across the environment, by storing the pheromone values in the RFID tags located there, as the user roams across the environment. The main point in favor of our approach is its extremely low price since it uses technologies (RFID) that are likely to be soon embedded in the scenario independently of this application. Relying on such an implementation, a wide range of application scenarios based on pheromone interaction can be realized ranging from multi-robot coordination, to monitoring of human activities. In this paper, we describe an application consisting in an agent-based system to easily find

everyday objects (glasses, keys, etc.) forgot somewhere in our homes. In particular, the application allows everyday objects to leave virtual pheromone trails across our homes to be easily tracked afterwards. It is worth emphasizing that current trends indicate that within a few years, many household objects and furniture may be RFID-tagged before purchase, thus eliminating the overhead of tagging. Moreover, some handheld devices start to be provided with RFID reading and writing capabilities (the Nokia 5140 phone can be already equipped with a RFID reader)" [14]

In a reversal of the mimicking of insect behavior by robots, DARPA is also experimenting with turning insects into robots. As reported online by TheCheers.org: "Inspired by Thomas Easton's 1990 novel *Sparrowhawk*, in which animals enlarged by genetic engineering were fitted with implanted control systems, the Defence Advanced Research Projects Agency (Darpa) is preparing to do the same with insects. The aim of the scientists is to insert micro-systems into insects as they undergo metamorphosis. In fact, the plan is that their organs will grow around the chips and wires that make up the remote-control devices. Darpa's main goal is to create cyborg insects that can fly at least 100 metres from their controller and land within 5 metres of a target and stay there until commanded to buzz off again. In a series of video-clips shown at a conference in Tucson, a tobacco hawkmoth with wires connected to its back lifts and lowers one wing, then the other, then both, in response to signals delivered to its flight muscles. The clips were filmed at the Boyce Thompson Institute in Ithaca, New York, where a team led by Dr David Stern implanted the flexible plastic probes into tobacco hawkmoth pupae seven days before the moths emerged." [15]



Jasmine robots swarming

The smallest-scale implementation of swarm robotics I've encountered is the University of California at Berkeley's Smart Dust project. As Doug Steel put it, "'Smart Dust' is an emerging technology made up from tiny, wireless sensors or 'motes.' Eventually these devices will be smart enough to talk with other sensors yet small enough to fit on the head of a pin. Each mote is a tiny computer with a power supply, one or more sensors, and a communication system.

"Smart dust motes are typically outfitted with environmental sensors which can monitor things like temperature, humidity, lighting, position, and acceleration. And one vendor, SkyeTek, sells a sensor that can read RFID tags.

"Already, researchers at the University of California, Berkeley, have developed a mote roughly the size of an aspirin tablet. This system was tested by transmitting weather information from Twin Peaks in San Francisco [my neighborhood] to a video camera in Berkeley, 21.4 kilometers across San Francisco Bay. For power, future motes could be supplemented by solar cells or even be powered by vibrations in the wall—a bit like a self winding wristwatch." [16]

In the process of researching this paper, I came upon an article from the August 30, 1999 issue of Business Week, credited to Neil Gross, number 14 of 21 Ideas for the 21st Century. I'd like to quote a few paragraphs from this article:

"In the next century, planet earth will don an electronic skin. It will use the Internet as a scaffold to support and transmit its sensations. This skin is already being stitched together. It consists of millions of embedded electronic measuring devices: thermostats, pressure gauges, pollution detectors, cameras, microphones, glucose sensors, EKGs, electroencephalographs. These will probe and monitor cities and endangered species, the atmosphere, our ships, highways and fleets of trucks, our conversations, our bodies--even our dreams.

"Ten years from now, there will be trillions of such telemetric systems, each with a microprocessor brain and a radio. Consultant Ernst & Young predicts that by 2010, there will be 10,000 telemetric devices for every human being on the planet. They'll be in constant contact with one another. But the communication won't be at our plodding verbal pace. 'Fifty kilobits per second is slow,' huffs Horst L. Stormer, a Nobel prize-winning physicist employed by Lucent Technologies Inc.'s Bell Laboratories and Columbia University. Machines will prefer to talk at gigabit speeds and higher--so fast that humans will catch only scattered snippets of the discussion.

"What will the earth's new skin permit us to feel? How will we use its surges of sensation? For several years--maybe for a decade--there will be no central nervous system to manage this vast signaling network. Certainly there will be no central intelligence. But many scientists believe that some qualities of self-awareness will emerge once the Net is sensually enhanced and emulates the complexity of the human brain.

"And though silicon networks today look nothing like the brain, nodes of the Net have begun to function as neurons. Researchers have already tackled complex computing problems, such as interpreting interstellar radio signals, by parceling computing tasks out to about a million PCs working in concert. Within 10 years, discrete microprocessors could be knitted together into ad hoc distributed computers. Don't think of these as PC networks. The terminals would just as likely be cell phones

or Palm-like devices, each one far smarter than today's heftiest desktops. 'Think of this as a whole ecology, an information environment that's massively connected,' says Ernst & Young Chief Technologist John Parkinson.

"Complexity experts anticipate the occurrence of such phenomena on a Net that will someday comprise billions of smart devices, each linked through thousands of pathways. The whole will add up to more than the sum of its parts, says Sandia National Laboratories Senior Scientist Gerold Yonas. 'At some point, a massively parallel computer will reconfigure itself,' he predicts, and portions of the Net will take actions that no human engineer programmed or even planned for.

"Now, toss into this ecosystem a few hundred million intelligent software agents, vastly more powerful than the crude software 'bots' that perform Web searches today. Add the voices and intentions of a few billion digital pets, companions, and caretakers. Then stretch out a sensory, telemetric fabric. 'The network itself becomes a huge digital creature,' says Toshitada Doi, chairman of Sony Corp.'s Digital Creatures Lab. 'We will carefully design it so that it will help human beings, not harm them.'" [17]

In a related article from the same issue, "Machines Will Be Smarter than We Are," by Otis Port, is this statement: "Swarms of microscopic robots will take up positions in the brain's sensory areas and create virtual-reality simulations that are impossible to distinguish from real reality."

The concept of the massive group mind that will fit the Earth like a skin reminds me of the conception of the oosphere, the massive group mind that was postulated by Teilhard de Chardin and Carl Jung, and envisioned by Philip K. Dick. From the microscopic group minds of "smart dust" to the macroscopic group mind of the Earth's electronic skin, individual intelligence will be seen to be manifested not as isolated, but as nodes in network fields that are, as former Star Wars architect Gerold Yonas put it, "greater than the sum of their parts."

References

[1] Gerkey, Brian P., Vaughan, Richard T., Howard, Andrew, "The Player/Stage Project: Tools for Multi-Robot and Distributed Sensor Systems," Proceedings of the International Conference on Advanced Robotics, pp. 317-323, Coimbra, Portugal, June 30-July 3, 2003.

[2] Harvey, I., Vaughan, E., and Di Paolo, E. A, "Time and motion studies: The dynamics of cognition, computation and humanoid walking." HART 2004, Fourth International Symposium on Human and Artificial Intelligence Systems: From Control to Autonomy. University of Fukui, Japan. 5-6 December 2004.

[3] Arkin, Ronald C., and Moshkina, Lilia, "Lethality and Autonomous Robots: An Ethical Stance," Technology and Society, 2007. ISTAS 2007. IEEE International Symposium on; 1-2 June 200, pp. 1-3, Las Vegas, NV.

[4] Koenig, S., Tovey, C., and Halliburton, W., "Greedy Mapping of Terrain," Robotics and Automation, Proceedings 2001 ICRA. IEEE International Conference on, Volume 4, Issue 2001, pp. 3594 – 3599, vol.4.

[5] E. Bahceci, O. Soysal, and E. Sahin, "A Review: Pattern Formation and Adaptation in Multi-Robot Systems," tech. report CMU-RI-TR-03-43, Robotics Institute, Carnegie Mellon University, October, 2003.

[6] Batalin, Maxim A., and Sukhatme, Gaurav S., "Sensor Coverage using Mobile Robots and Stationary Nodes", Proceedings of the SPIE, pp. 269-276, Boston, MA, August 2002.

[7] Beni, Gerardo., "Swarm Intelligence," presented at Seventh Annual Meeting of the Robotics Society of Japan, Tokyo, pp. 425-428, 1989.

[8] Payton, David, Estkowski, Regina, and Howard, Mike, "Compound Behaviors in Pheromone Robotics", Robotics and Autonomous Systems, 44 (3-4): pp. 229-240, Sept. 2003.

[9] Bayinddir, Levent, and Sahin, Erol, "A Review of Studies in Swarm Robotics", Turk. J. Elec. Engin., 15, (2007), pp. 115-147.

[10] Arai, Tamio, Pagello, Enrico, and Parker, Lynne E., "Editorial: Advances in Multi-Robot Systems", IEEE Transactions on Robotics and Automation, Vol. 18, No. 5, October 2002, pp. 655-661.

[11] Edelen, Mark Russell, "Swarm Intelligence and Stigmergy: Robotic Implementation of Foraging Behavior", Master of Science Thesis, 2003.

[12] Beckers, R., Holland, O. E., and Deneubourg, J.-L., "From local actions to global tasks: Stigmergy and collective robotics," presented at 4th International Workshop on the Synthesis and Simulation of Living Systems: Artificial Life IV, vol. 4, pp. 181-189, 1994.

[13] Fleischer, Jason G., and Troxell, Wade O., (1999), "Biomimcry as a tool in the design of robotic systems", Proceedings of the 3rd International Conference on Engineering Design and Automation.

[14] Mamei, Marco, and Zambonelli, Franco, "Spreading Pheromones in Everyday Environments via RFID Technology", 2nd IEEE Symposium on Swarm Intelligence, IEEE CS Press, June 2005.

[15] www.thecheers.org/news/Science/news_14688_Now-cyber-bugs-that-can-be-used-for-spying-into-enemy-territory.html

[16] Steel, Doug, "Smart Dust", UH ISRC Technology Briefing, March 2005.

[17] Gross, Neil, "The Earth Will Don an Electronic Skin," Business Week, August 30, 1999.

MEMBERSHIP FORM

YLEM yearly membership includes:
Directory An annual publication in which you are listed with approximately 250 other artists of new art forms
Journals The bi-monthly YLEM Journal contains articles on numerous topics along with news of members
Forums YLEM presents bi-monthly forums at San Francisco's Exploratorium, curates shows, and arranges special site visits
Web Site The YLEM website includes a link to member websites
Exhibits YLEM periodically showcases member work at prestigious galleries

Name

Business

Address

Home Phone

Work Phone

Email

Website

[ ] New member
[ ] Continuing member

How did you discover YLEM?

Please describe your work and/or interests as you would like it to appear in the directory in 30 words or less (attach additional pages if necessary)

Privacy:
[ ] Do not include me in the website directory
[ ] Do not include me in the annual directory
[ ] Do not include my name if the mailing list is sold to a member

Membership Rates:

US (Individual)	$40
US (Institution)	$60
US (Student/Senior)	$30
Contributing Member	$100
Donor Member	$300
Patron	$500
CyberStar Member	$1,000

Canada/Mexico add USD $5. All other countries ass USD $25 to cover shipping expenses. US currency only. Please mail a check or money order payable to YLEM, PO Box 31923, San Francisco, CA 94131-0923
For more information, contact us at ylem@ylem.org

YLEM

YLEM
JOURNAL

artists using science and technology

ylem [pronounced eye-lem]
-noun

1. Greek: for the exploding mass from which the universe emerged; the material of the universe prior to creation.

YLEM is an international organization of artists, scientists, authors, curators, educators and art enthusiasts who explore the Intersection of Arts and Sciences. Science and Technology are driving forces in contemporary culture, and YLEM members strive to bring the humanizing and unifying forces of art to this arena. YLEM members work in contemporary media such as Computer-Based Art, Kinetic Sculpture, Interactive Multimedia, Robotics, 3D Media, Film and Video.

Contact Information

MEMBERSHIP
members@ylem.org

JOURNAL
Loren Means
149 Evelyn Way
San Francisco, CA 94127
USA
lorenmea@pacbell.net

www.ylem.org